March 28, 2003

Ms. Maureen Ruskin
Occupational Safety and Health Administration
U.S. Department of Labor
Room N-3718
200 Constitution Avenue, N.W.
Washington, D.C. 20210

Dear Ms. Ruskin:

On October 11, 12, 13, and 16, 2000, a field survey to assess occupational hexavalent-chromium exposures and exposure-control technologies was conducted at two facilities (the "new facility" and the "old facility") of a company engaged in the manufacture of stainless steel and low alloy precision investment castings, designated Site 19 (Facility 9070), located in the state of Washington. Exposures may occur at this facility due to the use of chromium-containing ferrous metal alloys in the manufacturer of the castings. The field survey was conducted by personnel from Battelle Centers for Public Health Research and Evaluation, and Prezant Associates, under the direction of researchers from the Engineering and Physical Hazards Branch (EPHB), Division of Applied Research and Technology (DART), NIOSH. This survey was one of 21 conducted as part of a broader study of occupational hexavalent-chromium exposures and exposure-control technologies, the principal objectives of which are to:

- Identify and describe the exposure-control technology and work practices in use in operations associated with occupational exposures to hexavalent chromium, and to determine additional controls, work practices, substitute materials, or technology that can further reduce occupational hexavalent-chromium exposures.

- Measure full-shift, personal breathing-zone exposures to particulate-borne hexavalent chromium in air. These measurements will provide examples of exposures to hexavalent chromium among workers across the many industries where hexavalent chromium is encountered. These exposure data, along with the control data described above, are intended to illustrate typical conditions in the industries and operations selected for evaluation to the extent feasible.

Evaluation techniques. An initial meeting and a "walk-through" inspection of the site were conducted on October 11, followed by a comprehensive evaluation including full-shift air sampling on October 12 and 16 at the new facility and full-shift and partial-shift sampling on October 13 at the old facility. During the walk-through inspection, workers with potential exposures to hexavalent chromium were identified. Workers' full-shift exposures to hexavalent chromium in air were measured by placing on each selected worker a portable air-sampling apparatus consisting of a battery-powered pump that draws air through a collection medium, with the air inlet placed in the worker's breathing zone. Because the goal of this study is to assess the effects of engineering controls and work practices on hexavalent chromium exposures, the samplers' air inlets were placed outside of any respiratory or personal protective equipment worn by the workers. Eight short-term, task-specific personal breathing-zone air samples also were collected for hexavalent chromium. In addition, general-area air samples were collected in selected locations, both for hexavalent chromium and for iron and total chromium. The sample-collection media then were transported to DataChem Laboratories (DCL) in Salt Lake City, Utah, where they were analyzed for the collected mass of hexavalent chromium or iron and total chromium, as appropriate. From these analytical results, concentrations in air were calculated; the results are provided in Enclosure 1. The methods used for collecting the data were outlined in the study protocol and fact sheet that were provided prior to the field survey and are detailed in Enclosure 2. Descriptive information was collected about this industry and this facility's processes, methods, work practices, and exposure controls, including the costs associated with their installation, operation, and maintenance. This information also is recorded in Enclosure 2.

Evaluation criteria. The NIOSH researchers evaluate workers' exposures to hexavalent chromium in air by comparing measured exposures with criteria established by NIOSH, the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor, and the American Conference of Governmental Industrial Hygienists (ACGIH). The NIOSH recommended exposure limit (REL) for hexavalent chromium (Cr[VI]) is 1 microgram of Cr(VI) per cubic meter of air (1 $\mu g[Cr(VI)]/m^3$, or simply 1 $\mu g/m^3$) for all hexavalent chromium compounds, for a 10-hour time-weighted average exposure. NIOSH considers all hexavalent chromium compounds to be potential occupational carcinogens. The current, legally enforceable OSHA permissible exposure limit (PEL) for worker exposures to hexavalent chromium in air, expressed in terms of chromic acid (Cr[VI] trioxide, or CrO_3) concentration, is a "ceiling value" of 100 $\mu g(CrO_3)/m^3$ (which equals approximately 50 $\mu g(Cr[VI])/m^3$). This ceiling value represents a maximum concentration that a worker's exposure should not exceed at any time during the workday and applies to exposures to both chromic acid and chromates. ACGIH recommends Threshold Limit Values (TLVs®) for hexavalent chromium of 50 $\mu g/m^3$ for water-soluble compounds (such as sodium dichromate) and 10 $\mu g/m^3$ for insoluble compounds, both expressed in terms of Cr(VI) concentration and both for 8-hour time-weighted average exposures. ACGIH classifies hexavalent chromium compounds as human carcinogens.

Results and discussion. The results of the air sampling for hexavalent chromium, total chromium, and iron are provided in Enclosure 1. Among 31 full- and partial-shift personal breathing-zone (PBZ) and general-area air samples collected for hexavalent chromium, Cr(VI) was detected in 27 samples and was measured at quantifiable levels in 12 of those. Among eight short-term, task-specific PBZ samples, hexavalent chromium was detected in two samples but was next present in either at fully quantifiable levels. Reported values for Cr(VI) concentrations in air represent the average concentrations during the time periods sampled, and have not been converted to 8-hour or 10-hour time weighted averages. Therefore, comparisons to occupational exposure limits are approximate. Respiratory protection was not worn so the measured PBZ exposure levels are representative of these workers' actual exposures.

The measured full-shift PBZ exposures to Cr(VI) in the Melt Areas were greatest for the Lead Melter on Day 1 of the survey (at 0.10 $\mu g/m^3$), and for the Finisher 1 on Day 2 (at 0.19 $\mu g/m^3$). The full-shift exposures for the others in the Melt Areas were lower, ranging between 0.02 and 0.057 $\mu g/m^3$ at the new facility. Only one PBZ exposure at old facility was detectable at an estimated concentration of 0.02 $\mu g/m^3$. The highest exposure for the welders was for Welder 1, with exposures of 22 $\mu g/m^3$ on Day 1 and 20 $\mu g/m^3$ on Day 2. The full-shift exposures for Welder 2 were lower at 0.37 $\mu g/m^3$ on Day 1 and 12 $\mu g/m^3$ on Day 2. NIOSH researchers do not believe the results for the welders are representative of typical welding activities at this facility since the amount of welding completed was reported to be two to three times normal. However, the results suggest that the welders are exposed above the NIOSH recommended exposure limit for hexavalent chromium.

Hexavalent chromium was detected in all eight of the general-area air samples in the New Facility, and for three of these, concentrations were fully quantifiable. The concentrations ranged from an estimated 0.01 $\mu g/m^3$ to 0.11$\mu g/m^3$ with the lunchroom having a concentration of 0.071 $\mu g/m^3$ on Day 2 of the survey.

Recommendations. The following recommendations may be effective in reducing the hexavalent chromium exposures described above.

3. Air entering the building at the new facility through the overhead door provides ventilation for the melting and pouring processes. However, due to the presence of an exhaust fan above the overhead door, much of the incoming makeup air is short-circuited and is immediately exhausted from the building. Relocation of the exhaust fan to the opposite side of the building from the overhead door will provide more effective ventilation to the melting, pouring, and heating processes.

4. Additional ventilation is recommended for exhausting the ceiling area above the melting and pouring processes in order to prevent buildup of airborne contaminants.

3 The ventilation in the Melt Area at the old facility was observed to be very effective as supported by comparison of exposure results between the two facilities. It is recommended similar ventilation be installed at the new facility.

4. Since there is currently no operational ventilation in the major welding areas, it is highly recommended that ventilation be installed.

5. Good personal hygiene and work practices should be observed by workers including hand washing before smoking, eating, and drinking. Smoking, eating, and drinking should be

prohibited at work stations and should be allowed only during breaks and within the designated lunch and break areas.

6. The engineer responsible for the company's health and safety programs should undergo training in industrial hygiene and occupational safety and health.

Report and project status. This letter and its Enclosures will serve as the final report to you on this field survey, and the information in these documents will be included in the final NIOSH report for the overall research study of hexavalent-chromium exposures and exposure-control technologies. If you have any questions or comments, please contact me by e-mail at amk1@cdc.gov or by telephone at 513/841-4363.

Sincerely yours,

Amir Khan
Chemical Engineer
Control Technology Section
Engineering and Physical Hazard Branch
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Enclosures

cc:
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SITE 19 – ENCLOSURE 1
RESULTS OF WORKPLACE-ENVIRONMENT SAMPLING

AIR SAMPLING

The air-sampling plan included personal breathing-zone (PBZ) sampling of the hexavalent chromium (Cr[VI]) exposures of employees predicted to have the greatest potential for exposure. A total of 39 full- and partial-shift and short-term task PBZ samples for Cr(VI) were collected in two different facilities during this survey. The partial-shift and some short-term task results were combined to compute full-shift time-weighted average (TWA) exposures. PBZ air samples were collected in the breathing zones of the employees working at the processes and operations potentially generating fume that contains Cr(VI). General-area samples were collected in the vicinity of selected processes. Air-sampling results, with the concentrations of Cr(VI) in air expressed as micrograms of Cr(VI) per cubic meter of air ($\mu g/m^3$), are shown in Table 1-1.

General-area air samples to measure concentrations of iron and total chromium were collected adjacent to and concurrently with ("side-by-side") some of with the general-area samples for hexavalent chromium. As discussed below, iron collected in an air sample may negatively interfere with the determination of Cr(VI) in the sample, so these additional samples were collected, in part, to assist in the interpretation of the Cr(VI) results.

Cr(VI) was detected in 29 of 39 air samples of all types collected. The reported results represent the average concentrations measured during the actual sampling time periods. Respiratory protection was not worn so the measured PBZ exposure levels are representative of these workers' actual exposures.

Table 1-1.
Results of air sampling for hexavalent chromium.

Field Sample Number	Job Title/ Production Area	Sampling Date	Sampling Time (min)	Concentration of Cr(VI) in Air ($\mu g/m^3$)[A,B]	Full-Shift TWA Average Concentration of Cr(VI) in Air ($\mu g/m^3$)[B,C]
NEW FACILITY					
Melt Area – Day 1 – PBZ samples					
1056	Asst. Melter: a.m.	10/12/2000	362	(0.014)	
1068	Short-Term-Task	10/12/2000	30	<0.2	
1069	p.m.	10/12/2000	286	<0.02	(0.02)
1058	Lead Melter: a.m.	10/12/2000	400	(0.05)	

Field Sample Number	Job Title/ Production Area	Sampling Date	Sampling Time (min)	Concentration of Cr(VI) in Air ($\mu g/m^3$)[A,B]	Full-Shift TWA Average Concentration of Cr(VI) in Air ($\mu g/m^3$)[B,C]
1070	Short-Term-Task	10/12/2000	30	(0.7)	(0.1)
1072	p.m.	10/12/2000	234	(0.1)	
1057	Finisher 1: a.m.	10/12/2000	417	(0.02)	
1071	Short-Term-Task	10/12/2000	25	(0.80)	
1073	p.m.	10/12/2000	234	(0.04)	(0.06)
1059	Finisher 2	10/12/2000	628	(0.008)	(0.008)
1066	Production Mgr.	10/12/2000	421	(0.02)	(0.02)
	Welding – Day 1 – PBZ samples				
1060	Welder 1: a.m.	10/12/2000	167	67	
1067	p.m.	10/12/2000	369	0.69	22[D]
1061	Welder 2	10/12/2000	574	0.37	0.37
	Melt Area – Day 2 –PBZ samples				
1083	Asst. Melter	10/16/2000	701	(0.02)	(0.02)
1086	Lead Melter	10/16/2000	670	0.045	0.045
1084	Finisher 1	10/16/2000	712	0.19	0.19
1085	Finisher 2	10/16/2000	676	0.057	0.057
1089	Production Mgr.	10/16/2000	538	0.048	0.048
	Welding – Day 2 –Full-shift PBZ samples				
1088	Welder 1	10/16/2000	560	20	20[D]
1087	Welder 2	10/16/2000	664	12	12[D]
	Melt Area – Short-Term – Task PBZ Samples – Day 2				
1098	Asst. Melter: Short-Term-Task	10/16/2000	17	<0.2	N.A.
1099	Lead Melter: Short-Term-Task	10/16/2000	17	<0.2	N.A.
1100	Finisher 2: Short-Term-Task	10/16/2000	15	<0.2	N.A.
	General – Area Samples				
1062	Center I-Beam(East)	10/12/2000	525	(0.01)	(0.01)
1063	Shelf Near Shell Room(West)	10/12/2000	542	(0.02)	(0.02)
1064	Supply Shelf(East)	10/12/2000	427	(0.04)	(0.04)
1065	Lunchroom	10/12/2000	441	(0.011)	(0.011)
1090	Inside Roll-Up Door (West)	10/16/2000	649	(0.04)	(0.04)
1092	Supply Shelf(East)	10/16/2000	676	0.088	0.088
1095	Center I-Beam(East)	10/16/2000	612	0.11	0.11
1096	Lunchroom	10/16/2000	582	0.071	0.071

Field Sample Number	Job Title/ Production Area	Sampling Date	Sampling Time (min)	Concentration of Cr(VI) in Air $(\mu g/m^3)^{A,B}$	Full-Shift TWA Average Concentration of Cr(VI) in Air $(\mu g/m^3)^{B,C}$
OLD FACILITY *Melt Area – PBZ sample*					
1075	Lead Melter 1	10/13/2000	211	<0.02	N.A.
1074	Lead Melter 2	10/13/2000	453	(0.02)	(0.02)
1079	Melt Helper	10/13/2000	256	<0.02	N.A.
Melt Area – Short-Term –Task PBZ Samples					
1080	Lead Melter: Short-Term-Task	10/13/2000	21	<0.2	N.A.
1081	Melt Helper: Short-Term-Task	10/13/2000	25	<0.1	N.A.
General-Area Samples					
1076	Between Melt & Finish	10/13/2000	407	(0.01)	(0.008)
1078	Lunchroom	10/13/2000	372	<0.01	<0.008

Where:

[A] A concentration value in parentheses indicates a value calculated from a Cr(VI) mass between the limit of detection (LOD) for this sample set of 0.01 µg per sample, and the limit of quantification (LOQ) of 0.05 µg per sample. These concentration values are less precise than quantified values. A concentration value preceded by a “<” (“less-than” symbol) indicates a value below the LOD.

[B] Reported values for Cr(VI) concentrations in air, for both individual samples and combined, full-shift, time-weighted averages (TWAs), represent the average concentrations during the actual sampling time periods and the combined, time-weighted average periods. Neither types of values have been converted to ***8-hour*** or ***10-hour*** time weighted averages. Therefore, comparisons to occupational exposure limits are approximate.

[C] Full-shift time-weighted average (TWA) concentration of Cr(VI) in air is determined from two or three sequential air samples, whenever collected for a given worker's shift, and equals the concentration from the single sample when only one was collected. For TWA concentrations calculated from two samples, a value in parentheses indicates that at least one of the two concentration values was based on a mass value between the LOD and LOQ or below the LOD. (Refer to individual-sample concentration column to determine specific constituents of TWA in each such case.) When calculating TWAs, the reported individual-sample concentration value was used for fully quantified values and values between the LOD and LOQ. When one of the two concentrations was below the LOD, log-normal distribution of the data was assumed, and the central tendency for that concentration was determined (using the ***x/_2*** method of Hornung and Reed) and used in the TWA calculation. (Reference citation: Hornung, R.W., L.D. Reed, “Estimation of Average Concentration in the Presence of Nondetectable Values,” ***Appl. Occup. Environ. Hyg. 5[1]***, January 1990.)

[D] Although the reported values for Cr(VI) concentrations in air were not converted to a 10-hour TWA, the full-shift personal breathing-zone exposure appear to exceed the NIOSH REL of 1 $\mu g/m^3$ for 10-hour TWA exposure for these samples.

Cr(VI) = Hexavalent chromium. **TWA** = Time-weighted average. **NA** = Not applicable.

Summary statistics for selected groups of air-sampling results are provided in Table 1-2. The groups are pooled by process location and by sample type (PBZ or general area). The statistics include the number of samples in each group, and the range, median (geometric mean), and geometric standard deviation of the full-shift TWA Cr(VI) concentrations in each group. Only the new facility is included because there was only one full-shift sample in any potential "group"from the old facility.

Table 1-2.
Summary statistics for hexavalent chromium air-sampling results.

Description of Sample Group and Sample Type (PBZ on General Area)	Number of Samples	Range of Cr(VI) Full-Shift TWA Concentrations in Air ($\mu g/m^3$)[A]	Geometric Mean of Cr(VI) Full-shift TWA Concentrations in Air ($\mu g/m^3$)	Geometric Standard Deviation of Cr(VI) Full-Shift TWA Concentrations in Air
NEW FACILITY				
Melters	4	(0.02) - (0.1)	0.04	2.2
Finishers	4	(0.008) - 0.19	0.05	3.7
Areas East of Furnaces	4	(0.01) - 0.11	0.06	0.05
Areas West of Furnaces	2	(0.02) - (0.04)	NA	NA
Welders	4	0.37 - 22	6.6	7.0
Production Mgr	2	(0.02)-0.048	NA	NA

Where: **Cr(VI)** = Hexavalent chromium. **TWA** = Time-weighted average. **PBZ** = Personal breathing-zone.
[A] Refer to Footnotes A through C of Table 1-1 for explanation of concentration values listed in parentheses. Also, note that, as in Table 1-1, reported values for Cr(VI) time-weighted average (TWA) concentrations in air represent the average concentrations during the actual sampling time periods and the combined, time-weighted average periods. Neither types of values have been converted to ***8-hour*** or ***10-hour*** time weighted averages. Therefore, comparisons to occupational exposure limits are approximate.

As noted above, iron collected in an air sample for Cr(VI) may negatively interfere with the determination of Cr(VI) in the sample. Specifically, if the sample contains a relatively high content of bivalent iron (Fe[II]) compared to the Cr(VI) content, the Fe(II) has the potential for causing negative interferences before and during Cr(VI) laboratory analysis, by reducing Cr(VI) to trivalent chromium (Cr[III]), which in turn may lead to the under-reporting of Cr(VI) concentrations in air. This is explained in the "Methods" section of Enclosure 2. Although the Cr(VI) analytical method is designed to control this potential problem, estimating the iron content of the airborne particulate remains important. Estimating the total chromium (Cr) content of the particulate also can help bring context to the reported Cr(VI) results, since, as a form of Cr, the Cr(VI) content by definition must be less than or equal to the total Cr content. Partly to help address this issue, three full-shift general-area air samples for total chromium and iron were collected and analyzed, and the results of these samples, are provided in Table 1-3.

The results of these air samples reveal that particulate-borne iron was measured in the air of the work areas at concentrations ranging from 50 to 100 μg/m^3, exceeding the reported levels of hexavalent chromium in the air. The analytical method cannot distinguish between Fe(II), trivalent iron (Fe[III]), and metallic iron (Fe[0]), but all three are stable forms so the NIOSH researchers expect that an appreciable portion of the iron in the metal fume formed in processes such as found at this facility would be in the form of Fe(II). Therefore, it is likely that concentrations of Fe(II) also greatly exceeded those of Cr(VI).

If Fe(II) is collected along with Cr(VI) in a sample, the potential for reduction of the Cr(VI) exists during sample collection and storage, and during Cr(VI) analysis. However, the NIOSH researchers do not believe that the nature of the metal-fume particulate after collection onto the filters favors the interaction necessary for this to occur after collection and during storage. The collected particulate is in the solid physical state and there is no evidence of substantial moisture that would favor dissociation of and interaction between the ions of interest. (Humidity levels were modest, as subsequently reported in this Enclosure. See Table 1-4.) During analysis, the procedures employed have been shown to be highly effective in controlling the reduction of Cr(VI) even at a 10-to-1 excess of Fe(II) over Cr(VI). Although in some cases Fe(II) may be present here in greater than 10-to-1 excess, the use of a buffering solution to control the pH during analysis is expected to provide adequate control to assure acceptably accurate results. Therefore, the NIOSH researchers believe the results for Cr(VI) in air presented here are the best available estimates of the "true" concentrations.

Table 1-3.
Results of general-area air sampling for total chromium and iron.

Date (2000)	Sample #	Location	Sample Volume (m^3)	Sample Time (min)	Total Cr Conc. in Air[A] (μg/m^3)	Fe Conc. in Air (μg/m^3)
NEW FACILITY						
Oct 16	1091	Inside Roll-Up Door	1.3	649	2.5	55
Oct 16	1092	Supply Shelf	1.2	616	5.2	100
OLD FACILITY						
Oct. 13	1077	Between Foundry and Finishing	0.70	348	(1.3)	50

Where:

[A] A concentration value in parentheses indicates a value calculated from a Cr(VI) mass between the limit of detection (LOD) for this sample set of 0.05 µg per sample, and the limit of quantification (LOQ) of 0.1 µg per sample.
Cr = chromium **Fe** = Iron

TEMPERATURE AND RELATIVE HUMIDITY

Table 1-4 shows the data collected inside and outside the new and old facilities during the survey. If a range of temperatures is listed, the lower temperature represents the average work area temperature with the oven door closed and the higher temperature is with the oven door opened.

Table 1-4.
Temperature and relative humidity at both facilities

Date (2000)/ Time	Indoor Temperature (°F)	Outdoor Temperature (°F)	Indoor Relative Humidity (% RH)	Outdoor Relative Humidity (% RH)
NEW FACILITY				
Oct. 12, 6 a.m.	74.5	59.2	41	77
Oct. 12, 7 a.m.	75.9	-	38	-
Oct. 12, p.m. (during pour near furnaces)	70	-	42	-
Oct. 12, p.m. (5 feet downwind during pour)	106	-	26	-
Oct. 16, 6 a.m.	67.0	-	43.9	-
Oct 16, 7 a.m. (during pour)	86.4	-	29.6	-
Oct. 16, 11 a.m.	90.2	-	33.4	-
Oct. 16, p.m.	76.8 - 82.4	67.1	-	-
OLD FACILITY				
Oct. 13, a.m. (furnace area)	72- 88	68	61	59
Oct. 13, a.m. (lunchroom)	68	-	61	-
Oct. 13, p.m.	75	-	62	-

(furnace area)				
Oct. 13, p.m. (lunchroom)	70		62	

HISTORICAL DATA

No previous hexavalent chromium exposure sampling has been completed at either facility.

SITE 19 – ENCLOSURE 2

PROJECT AND FACILITY INFORMATION

BACKGROUND

The National Institute for Occupational Safety and Health (NIOSH), working under an inter-agency agreement with the Office of Regulatory Analysis (ORA) of the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, is conducting a study to quantitatively characterize occupational exposures to hexavalent chromium and to document engineering controls and work practices affecting those exposures. Hexavalent chromium is classified by NIOSH as a potential occupational carcinogen, and is widely used in industry in the United States. The potential for worker exposures to hexavalent chromium has been identified in industrial sectors represented by at least 46 different two-digit Standard Industrial Classification (SIC) codes. A review of OSHA's Integrated Management Information System (IMIS) database from 1994 shows that many workers in a variety of industries are exposed to hexavalent chromium in air at concentrations exceeding the recognized occupational exposure limits enumerated below. Therefore, there is a need to characterize hexavalent chromium exposures, their causes, and the measures which are or which could be employed to reduce them (e.g., engineering controls, work practices, and personal protective equipment).

The performance of thorough industrial hygiene field surveys in a variety of workplaces will provide valuable and useful information to participating employers and their employees, other employers and workers in the affected industries, and the occupational health community at large. NIOSH has conducted 21 case-study assessments to document existing controls and the associated worker exposures to hexavalent chromium in a variety of industrial processes and operations. The current field survey constitutes one of these 21 case studies. This industrial operation was selected for evaluation because chromium is used in the manufacture of precision parts. Field surveys for this study are directed by NIOSH research personnel and are conducted by Battelle Centers for Public Health Research and Evaluation and their subcontractor, Prezant Associates.

The currently recognized routes of exposure for hexavalent chromium are inhalation, ingestion, and dermal contact. Inhalation is the primary route of exposure associated with evidence of increased incidence of lung cancer, so the focus of this study is on exposures to the particulate-borne hexavalent chromium in the air. However, practices and situations that could be a factor in ingestion and dermal exposure also are evaluated as part of the study.

The NIOSH researchers evaluate workers' exposures to hexavalent chromium in air by measuring these exposures and comparing the measured levels with criteria established by NIOSH itself, OSHA, and the American Conference of Governmental Industrial Hygienists (ACGIH). These organizations establish exposure limits reflecting the levels to which they believe, based upon thorough review of the relevant scientific literature, that nearly all workers repeatedly may be exposed, day after day for 40-hour work weeks throughout a working lifetime, without adverse health effects. In contrast with NIOSH and ACGIH, OSHA also is required to consider, when setting a legally enforceable "permissible exposure limit" (PEL), the feasibility of meeting the proposed limit.

The NIOSH recommended exposure limit (REL) for hexavalent chromium (Cr[VI]) is 1 microgram of Cr(VI) per cubic meter of air (1 $\mu g[Cr(VI)]/m^3$, or simply 1 $\mu g/m^3$) for all hexavalent chromium compounds, for a 10-hour time-weighted average exposure. NIOSH considers all hexavalent chromium compounds to be potential occupational carcinogens. The current OSHA PEL for worker exposures to hexavalent chromium in air, expressed in terms of chromic acid (Cr[VI] trioxide, or CrO_3) concentration, is a "ceiling value" of 100 $\mu g(CrO_3)/m^3$ (which equals approximately 50 $\mu g(Cr[VI])/m^3$). This ceiling value represents a maximum concentration that a worker's exposure should not exceed at any time during the workday, and applies to exposures to both chromic acid and chromates. ACGIH recommends Threshold Limit Values (TLVs®) for hexavalent chromium of 50 $\mu g/m^3$ for water-soluble compounds (such as potassium dichromate) and 10 $\mu g/m^3$ for insoluble compounds, both expressed in terms of Cr(VI) concentration and both for 8-hour time-weighted average exposures. ACGIH classifies both soluble and insoluble hexavalent chromium compounds as confirmed human carcinogens. Separately, ACGIH has established TLVs for four specific inorganic hexavalent chromium compounds, based on additional studies. These substances, and their respective TLVs for 8-hour time-weighted average exposures, expressed in terms of Cr(VI) concentration in air, are as follows: strontium chromate, 0.5 $\mu g/m^3$; calcium chromate, 1 $\mu g/m^3$; zinc chromate, 10 $\mu g/m^3$; and, lead chromate, 12 $\mu g/m^3$. ACGIH also recommends a TLV for an 8-hour time-weighted average exposure to chromyl chloride (CrO_2Cl_2) vapor of 0.025 parts per million (approximately 160 $\mu g[CrO_2Cl_2]/m^3$ or 54 $\mu g[Cr(VI)]/m^3$). Finally, ACGIH recommends a ceiling TLV for tert-butyl chromate of 100 $\mu g/m^3$, expressed as an equivalent concentration in air of CrO_3 – which equals approximately 50 $\mu g(Cr[VI])/m^3$ – with a "skin" notation, which indicates that direct skin contact may combine with the inhalation exposure to increase the overall absorbed dose.

METHODS

This field survey was conducted in accordance with the Code of Federal Regulations, Title 42, Part 85a (42 CFR 85a), the NIOSH regulations governing the investigation of places of employment. An introductory meeting with operations management was completed on October 11, 2000. Following the meeting, a "walk-through" tour of the production area and other areas of the facility was conducted, during which the industrial-hygiene assessment of exposure and control technology was begun. Employees with the highest potential for hexavalent chromium exposures in each process area or operation were the major focus of the site visit, and were identified during the walk-through inspection. Workers selected for breathing-zone sampling were briefed on the sampling procedures to be conducted. In addition, personal and area monitoring and an assessment of control technologies were completed at the company's older facility on October 13, 2000.

Sampling data sheets were completed by the field survey team to document all of the samples collected. Information pertinent to process operation and control effectiveness (e.g., control methods, ventilation rates, work practices, specific process/operation details, personal protective equipment used, etc.) also was collected. A thorough description of the process is essential to understanding the role of engineering measures and work practices in the control of workers' exposures. Conversations were held with workers to determine if the days during which the exposure measurements were made were typical, in terms of work load and work practices, to help place the sampling results in proper perspective. Pertinent data on the employer and the industry also were collected, as was information regarding costs associated with the hazard-control engineering measures.

Full-workshift and shorter-term personal breathing-zone (PBZ) and general-area (GA) air samples for hexavalent chromium were collected using portable air-sampling apparatuses, each consisting of a battery-powered pump that draws air at a measured rate through a collection medium. Specifically, Gillian® Model 17G9 Gil-Air sampling pumps were used, with a nominal flow rate of 2 liters per minute (L/min). The pumps' air flow rates were pre- and post-calibrated using a Bios DryCal®, a primary air-flow calibration device. The sampling media employed were 37-mm diameter, 5-micron pore size, polyvinyl-chloride (PVC) membrane filters housed in polystyrene cassettes that were sealed with gel bands. For each PBZ sample, the sampler was placed on a selected worker with the air inlet placed in the worker's breathing zone. Because the goal of this study is to assess the effects of engineering controls and work practices on hexavalent chromium exposures, the samplers' air inlets were placed outside of any respiratory or personal protective equipment worn by the workers. Specifics on short-term and general-area air sample collection are provided at relevant points in the "Facility and Process Descriptions" section of this Enclosure.

After sample collection, the filters, including "field blanks" and quality-assurance (QA) samples, were sealed with gel bands, stored in coolers with cold packs, and shipped overnight to DataChem Laboratories, Inc., in Salt Lake City, Utah, for analysis. The filters were analyzed for hexavalent chromium using OSHA Method ID-215. This method involves the extraction of Cr(VI) from the PVC filter using an alkaline (carbonate/ bicarbonate/ magnesium[II]/ phosphate) buffer. After any necessary dilution, a measured portion of the buffer solution extract is injected into an ion chromatograph. Post-column derivitization of the Cr(VI) with 1,5-diphenylcarbazide is performed before the final Cr(VI) derivative is analyzed via an ultraviolet-visible (UV–Vis) detector at a wavelength of 540 nanometers.

The use of the alkaline buffer solution to extract the Cr(VI) from the filters largely eliminates an otherwise-massive negative interference from iron that may be collected in a given sample, which may reduce the Cr(VI) to trivalent chromium (Cr[III]) and thereby lead to the under-reporting of the mass of Cr(VI) that was on the filter prior to extraction. Specifically, this interference is associated with the oxidation-reduction reaction between bivalent iron (Fe[II]) and Cr(VI), in which the Fe(II) is oxidized to trivalent iron (Fe[III]) as the Cr(VI) is reduced to Cr(III). The use of the alkaline buffer limits such losses of Cr(VI) in solution to only 3% at aFe(II)-to-Cr(VI) ratio of 10-to-1, and even less at lower ratios. In part to help evaluate the potential for iron to act as a negative interferent with Cr(VI) collected in a sample, additional full-shift, general-area air samples were collected and analyzed for total chromium and iron using NIOSH Method 7300, modified for microwave digestion. This method does not distinguish between the valence states of iron (Fe[II] versus Fe[III]).

Laboratory analytical results of the air monitoring data are expressed in terms of mass (reported in micrograms [μg]) of hexavalent chromium for each sample. The analytical laboratory also determines a limit of detection (LOD) and a limit of quantification (LOQ) for the sample set. The LOD is defined as the lowest mass of Cr(VI) that can be distinguished from background; the LOQ is defined as the lowest mass of Cr(VI) that can be quantified with accepted precision. Both the LOD and LOQ are determined by analytical procedures which are not related to sampled air volumes. For the air-sample set at this site, the LOD was defined as 0.01 μg and the LOQ was defined as 0.05 μg. If the analytical result (mass) for a given sample is a value less than the limit of detection of the analytical method, the mass would be reported as "less than" the LOD value (e.g., <0.01 μg). If the analytical result (mass) for a given sample is a value between the LOD and LOQ, the mass would be reported as the actual analytical value in parentheses to indicate the lack of normally-accepted precision (e.g., [0.03 μg]).

"Field-blank samples" are used to estimate contamination which may occur during handling, shipping, and/or storage before analysis. A field-blank sample consists of an air-sampling filter in its cassette through which no air is drawn, but which otherwise is handled, shipped, and stored similarly to the air samples. Typically, at least one field blank is submitted for each ten air samples, with a minimum of two and a maximum of ten field blanks per sample set. At this site, five field blanks were submitted for analysis. No Cr(VI) was detected on any of these field-blank samples.

For each sample for hexavalent chromium, the Cr(VI) concentration in air may be

calculated using the analytical result for Cr(VI) mass and the air-sample volume: For a sample with a mass value less than the LOD, the ***concentration in air*** would be calculated using the LOD, and the result would be reported as "less than" that value (e.g., <0.01 $\mu g/m^3$). For a sample with a mass value between the LOD and LOQ, the ***concentration*** would be calculated using the reported mass value, and the result would be reported in parentheses to indicate lack of normally-accepted precision (e.g., [0.04 $\mu g/m^3$]).

The TSI VelociCalc Plus® thermoanemometer was used to collect relative humidity and air temperature data in the workplace and outside, and ventilation measurements for the local exhaust ventilation systems. Sensidyne / Gastec® smoke tester tubes were used to observe general airflow patterns in the work area.

FACILITY AND PROCESS DESCRIPTIONS

This field survey was conducted at two manufacturing plants operated by this company in the Pacific northwest region of the U.S., a newer, larger plant and an older: smaller plant. Manufacturing precision parts composed of stainless and low alloy steels is the company's primary activity. A wide variety of parts are produced for a broad range of industrial customers including aerospace, medical technology, automotive/marine, computer hardware, industrial pumps/impellers, and sporting equipment. The company has been in operation for 15 years and presently has 100 employees, approximately 50 at each of the two plants. Operations were started at the new facility during the first quarter of 1999. According to company management, this company is representative of medium-sized precision parts manufacturers utilizing investment casting. The facility is a non-union shop. The new facility is a 52,500 square foot (ft^2) building which includes corporate offices, a quality inspection laboratory, and a 42,000 ft^2 production area (see Figure 1 for the facility floor plan). Annual income is approximately $11 million. Alloy melting operations were identical at the two facilities yet the old facility had ventilation in the Melt Area. This report refers to the newer facility unless noted otherwise.

Of the 100 employees at both facilities, approximately 18 are involved in activities with the potential for exposure to hexavalent chromium, including 14 Melt Area workers and 2 welders. Of the employees potentially exposed to Cr(VI), those at the old facility have 5 to 12 years experience and at the new facility, 4 months to 20 years.

A. OVERALL PRODUCTION DESCRIPTION

This company uses primarily four types of castings in the manufacture of precision parts: corrosion-resistant castings (iron-chromium and iron-chromium nickel), low-alloy steel castings, stainless-steel and carbon-steel castings. The chromium content in the various types of castings ranged from <0.25% to 26%. American Society for Testing and Materials (ASTM) standard specifications for these three types of castings, material safety data sheets (MSDS), specification sheets and quality control spectrometer results can be found in Appendix A.

The melting area at the new facility had five 30,000-hertz (Hz) induction furnaces capable of melting three different sized batches, called "heats". The sizes were 150 pounds(1bs), 300 lbs, and 700 lbs. In a typical day, eight to thirteen 'heats' are completed. Average weekly production levels are 35,000-40,000 lbs.

This facility manufactured stainless and low-alloy steel precision parts. The chromium present in the stainless alloys was the potential source of hexavalent chromium. The typical pour temperatures ranged from 2,900^{O}F to 3,500°F, with 3,100°F being the median temperature. Workers were potentially exposed to hexavalent chromium during melting and pouring tasks as well as during repair welding tasks.

Production levels on the days and shifts sampled were reported as typical. Overall production for the year was also typical. At the time of the survey, the facility was operating one daily 10-hour shift, Monday through Thursday, with starting times varying in between 4:00 a.m. to 5:00 am depending upon job assignment. Some employees also work on Fridays for a half-day, as needed.

Two welders performed stick, gas-metal-arc welding (commonly known as metal inert-gas, or MIG, welding), gas tungsten-arc welding (commonly known as tungsten inert-gas, or TIG, welding) and carbon-arc gouging in the performance of repair work on castings and other in-house welding projects.

B. INDIVIDUAL PROCESS DESCRIPTIONS

1. Alloy Furnaces – New Facility

a. Equipment/Material Description

There were five 30,000-Hz induction furnaces in three capacities, 150 lbs, 300 lbs, and 700 lbs, at the new facility. There were three gas-fired ovens for heating molds. The lost wax investment molds were constructed in another area and brought to these ovens. The ceramic molds were then heated to 2,000°F to bring them up to a temperature compatible with the molten metal pour. Other equipment used in the area included transfer ladles for pouring the molten metal, temperature probes, low-profile wheeled carts loaded with sand, 30-gallon steel drums and an analytical spectrometer for alloy analysis.

b. Job Descriptions

Two employees worked at this location for the full shift, the Lead Melter and the Assistant Melter. They loaded and monitored the furnaces. Two other employees came from the Fabrication Area into the furnace area several times a day to assist in performing the pours of the molten metal. Each pour took 15-to-20 minutes depending upon the number and type of molds. All four workers participated in the pour, performing various tasks as described below. The term used for one complete run or batch in a furnace was a 'heat.' Heat sizes and number of molds poured per heat varied depending upon the furnace used.

c. Worker Activities Observed

Day 1

On this day, nine heats were completed, two stainless-steel (the first approximately 16% chromium [Cr], the second approximately 25% Cr), one carbon-alloy (<0.25% Cr) and six low alloy (the first five 0.86% Cr each and the last approximately 0.5% Cr).

Lead Melter: The Lead Melter and his assistant loaded the various furnaces with 15 to 20 different ingredients depending upon the type of alloy desired. The ingredients went in gradually with constant monitoring of temperature, time, and specific heat content. The Lead Melter participated in the addition of some of the ingredients but his primary function was to monitor the heat using temperature probes, to collect quality control (QC) samples of the heat, and analyze these samples for various parameters including metal content. The Lead Melter also added additional ingredients as needed to bring the heat into the required parameters' specifications. An MSDS for the topping compound, specification sheets for the alloys, and the ingredients in a typical heat can be found in Appendix A. As needed, the lead Melter also operated the forklift to move supplies and products.

During pours, the Lead Melter would collect QC samples from the crucible. Vapor and fume were present in his breathing zone for the few seconds he spent collecting these samples. As each pour was completed into a mold by the finishers, he quickly stepped to the side of the mold and poured a hot topping compound on top of the molten metal in the neck of the mold. This aided in slowing uneven cooling of the molten metal, to prevent cracks in the casting. Personal protective equipment (PPE) worn included darkened safety glasses during pours, steel toed-boots, and gloves. This employee did not don any type of protective suit or apron during his work shift so his air sampler's air inlet (i.e., filter cassette) was always located outside his PPE. The employee worked through lunch, which was his choice and his normal practice. His air-sampling apparatus remained on and running during this time.

Assistant Melter: This employee loaded the various metals and metal alloys into the furnaces. He kept the area swept and clear of spilled materials, operated a forklift to move drums and supplies, and prepared carts which held the molds during the pour. He was also responsible for loading the gas-fired ovens with ceramic transfer ladles and the ceramic molds for pre-heating. During pours, he removed molds one at a time from the oven and placed them in a bed of sand on a low-profile cart. These carts were located between the ovens and the furnaces. Only one cart was used at a time. He also placed inverted steel drums over the top of the molds at the completion of the pours. The PPE worn included darkened safety glasses, steel-toed boots, leather gloves, and during pours a full aluminized heat-protective suit and mitts for handling the hot ceramic molds. For most of the shift, this employee's air-sampling filter cassette was located outside his PPE. When he donned the full heat suit, however, it was located under the hood of the suit. Due to the extreme temperatures present when he leaned into the ovens, it was thought best to protect the filter from the heat. The temperature and relative humidity (RH) sensor was taped under his hood next to the cassette during one pour. The maximum readings were 96.8 °F and 94% RH. This employee worked through lunch which was his choice and his normal practice. His air-sampling apparatus remained on and running during this time.

Finishers 1& 2: These two employees worked in the finishing area most of the day performing grinding, polishing, and sand-blasting operations on castings. When the Lead Melter and his assistant had a heat ready to pour, a loud horn sounded throughout the plant indicating that a pour was about to occur. The area between the ovens and the furnaces where the pours occurred was off-limits during pours except for the four employees performing the pour. The two finishers came to the furnace area, donned their PPE, and obtained a pre-heated transfer ladle out of the oven from the Assistant Melter.

Stepping to the furnace, one finisher actuated the mechanism that tilted the furnace crucible forward to dispense molten metal into the two-handled transfer ladle. One handle on the transfer ladle was straight, the other a square fork. One finisher was on each side of the transfer laddle. Pouring was accomplished when the finisher with the forked handle rotated the handle to tip the ladle allowing molten metal to flow into the mold. One to four molds were filled per ladle, depending upon the size of the mold. The ladle was refilled at the crucible as many as twelve times for each heat. The breathing zones of both employees were within three feet of the furnace crucible and ladle during dispensing. Fumes and vapors were visible around their face shields. During the shift, their total approximate time spent pouring was 180 minutes.

PPE worn included full heat-protective aprons with long sleeves, heat-protective gloves, face shields, and steel-toed boots. Both employees' air sampling filter cassettes were located outside their protective aprons and at the bottom edge of their face shields.

The work location at Finisher 1 in the Finishing Area was approximately 40 feet from the welder's work stations. The work location at the Finisher 2 in the Finishing Area was approximately 15 feet from the general welding area and 30 feet from the carbon-arc gouging station. Both of these employees took a 30 minute lunch break. The break was taken at the picnic tables located inside the building at the edge of the production area. Their sampling apparatus remained on and running during this time.

Short-Term Samples

Task-specific PBZ air samples for Cr(VI) were collected for the Lead Melter, Melt Assistant, and Finisher 1 on Day 1. The Lead Melter collected a Qc sample from the melt, poured additives in, mixed the melt, and took temperatures while wearing the task-specific sampler. The Melt Assistant's task sample was collected just after the scrap metal had melted in the furnace crucible, at which time he mixed the melt and added other ingredients. The task sample for Finisher 1 was collected while he performed a pour. On Day 2, the task samples for the Melters were collected during the same activities as Day 1. Finisher 2 had a task-specific sample collected during pouring.

Day 2

On this day, eleven heats were completed; five stainless-steel (the first two approximately 17% already defined Cr, the second two approximately 25% Cr, and the last heat approximately 19% Cr), and six low alloy (all approximately 0.86% Cr). Activities for the personnel were the same as described above for Day 1. The only difference between Day 1 and Day 2 was the types of heats completed. Also, on Day 1, all employees left the work area for a 30- minute staff meeting.

Production Manager: The manager was observed in the production area several times during both days of the survey, consulting with the Melters and other personnel. He observed pouring activities from a distance.

2. Alloy Furnace – Old Facility

Although the primary interest for visiting this sister facility was to observe the ventilation system in the Melt Area, there was an opportunity to also evaluate the PBZ exposures to Cr(VI), and the work activities, of employees in the area while they were performing routine activities. The activities and exposures of three employees, two Lead Melters and one Assistant Melter, were evaluated, one Lead Melter for a full shift and the other employees for partial shifts. One of the Lead Melters worked from 1:00 a.m. to 9:00 a.m. and the second worked from 5:00 a.m. to 1:00

p.m. The Assistant Melter also worked from 5:00 a.m. to 1:00 p.m. These are the two shifts during which the furnaces are operated.

a. Equipment/Material Description

There was one 300 lb induction furnace at the old facility. Other equipment and activities were the same as the new facility above.

b. Job Descriptions

Starting at 5:00 a.m., there were two Lead Melters working at this location. Lead Melter 1 completed two melts before 5:00 a.m. and before the start of the evaluation. Once the Cr(VI) air samples were started, Lead Melter 2 prepared two melts between 5:30 a.m. and 9:00 a.m. The two worked together to do these two pours. After 9:00 a.m., when the work shift of Lead Melter 1 was finished, Lead Melter 2 performed the rest of the melts for the day. A new Assistant Melter came to the area to assist when it was time to pour. Each pour took five to ten minutes to complete. Eight to ten molds were filled in each pour. The transfer ladle was refilled at the furnace four times for each pour. Heat sizes and numbers of molds poured were less than at the other facility.

c. Worker Activities Observed

On the single day at which this process was evaluated at the old facilty, five heats were completed: one stainless-steel (approximately 16% chromium [Cr]), one carbon-alloy (<0.25% Cr), and three low alloy (approximately 1% Cr each).

> *Lead Melters*: The Lead Melters performed all the activities described at the new facility for the Lead Melter and also loaded all the starting materials into the furnace. Only one furnace was in operation and the number of molds filled was fewer for each melt. As previously mentioned, the Lead Melters also performed the pouring either together or along with the Assistant Melter. PPE worn included heat-protective aprons, heavy-duty leather gloves, face shields, and steel-toed boots. Lead Melter 1 assisted in three pours while his exposures and activities were evaluated for a partial shift. One of these melts was carbon steel containing <0.25% Cr and the other two were low alloy containing approximately 1% Cr. Lead Melter 2 prepared five melts and assisted in the pouring of all five. The chromium content is listed in the first paragraph above.
>
> *Assistant Melter:* This employee worked in the finishing area grinding and polishing castings and in the Melt Area loading the ovens with ceramic molds and ladles and assisting in the pouring of melts. He assisted with four pours during his shift, completing one of these pours before the start of the evaluation of his activities and exposures, which was conducted for a partial shift. PPE worn included coveralls, heavy-

duty work gloves or a heavy-duty leather mitt, aluminized sleeves, a face shield, and steel-toed boots.

Short Term Samples:

Task-specific PBZ air samples for Cr(VI) were collected for Lead Melter 2 and the Assistant Melter during the stainless-steel pour.

3. Welders – New Facility

a. Equipment/Material Description

The types of work performed in the new facility included shielded metal-arc cutting(SMAC), TIG welding, and MIG welding. Carbon-arc gouging was also performed. All types of welding used Miller power supplies. The filler rods and electrodes used were of the same base metal as the carbon-steel, low-alloy and stainless-steel melts produced in the Melt Area.

b. Job Descriptions

There were two employees who performed welding to repair castings. They did not weld full-time but performed other activities such as grinding on completed castings, stamping numbers on parts, strength testing and heat treating of castings, and quality-control activities. Only the welding activity presented the potential for hexavalent chromium exposure. Carbon-arc gouging usually only occurs once a month. The other types of welding are performed when enough parts accumulate that need repair. This occurs usually two days per week for approximately three hours. Welder 1 is the primary welder with Welder 2 performing some welding and a greater percentage of the administrative work.

There were not a sufficient number of parts on hand during the survey days to perform the typical welding tasks, so the welding work was simulated on the various base metals using the different types of welding methods. Due to what is thought to have been a misunderstanding regarding the intention of the simulation, all the welding tasks were grouped together in a short time frame, resulting in two to three times the typical welding load, most performed in a much shorter time period than normal. This resulted in airborne concentrations believed to be higher than typically achieved in a routine eight hour day.

c. Worker Activities Observed

Table 2-1.
Welder Activities: Base Metals and Welding Rods.

Welder	Base Metal	Welding Rod
1	ASTM A356	ER70S-2

1	ESCO 12F (proprietary)	ER70S-2
1	A743 CF3M (316L)	E316-16 & 316-L
2	CD4MCu	gouging

Day 1

Welder 1: This worker performed simulations of typical MIG and TIG welding and shielded-metal arc welding (SMAW). He also performed grinding on the parts once the welding work was completed. The MIG welding was done with 70S mild steel wire. A summary of welding materials is listed in Table 2-1. The MSDs and information related to the ASTM specifications followed by the welders can be found in Appendix F. All these welding tasks were performed in a welding area surrounded by welding curtains. The ventilation systems were non-operational. See the discussion of engineering controls in the next section of this enclosure.

Welder 2: The majority of the day was spent performing administrative tasks and some QC testing. A limited amount of welding was done. One carbon-arc project was completed. The carbon-arc gouging was performed on the highest chromium-content casting produced at the facility, approximately 25% chromium. A semi-circular section of the casting, approximately 6 inches long and 1½ inches in depth, was removed. This work took approximately five minutes and was performed in an area surrounded by welding curtains on three sides and a large ventilation hood on the fourth side which was not operational. There was an outside door open along the same wall as the hood, approximately eight feet from the work area. Such carbon-arc gouging projects typically take five to ten minutes.

Day 2

Welder 1: This worker performed activities similar to those described for Day 1.

Welder 2: This worker performed carbon-arc gouging as on Day 1, tensile-strength QC testing, and other administrative activities.

DESCRIPTION OF HAZARD CONTROL MEASURES

A. LOCAL EXHAUST VENTILATION

There was no local exhaust ventilation at the new facility. Thermal convection carried vapor and fume generated by the furnaces upward. Once reaching the ceiling, vapors and fumes were observed rolling back down towards the work area. The company has retained a ventilation engineering design firm and at the time of the survey plans were being developed to install local ventilation in several work locations at the facility. The company had purchased a 40-years old pre-owned American Air Filter "skimmer"(centrifugal precipitator), 60 horsepower (h.p.) fan, and cloth-tube baghouse. The volumetric air flow capacity of this used system is approximately 18,000 to 19,000 cubic feet per minute (cfm). See Appendix B for details about the system.

Basic design parameters are as follows:

Fan: Model 30K
Volumetric airflow rate =18,000 to19,000 cfm
Total static pressure(s.p) capacity = 12 inches of water
Motor power = 60HP
electrical motor requirements = 440 volts, 60 Hz, 3-phase alternating current(AC).

Dust collectors: Baghouse Model Amer-Tube 166 "Skimmer" Size 27
Pressure differential across the "skimmer"= 2.5 to 3 inches of water static pressure loss.
Pressure differential across the baghouse = 4 inches of water static pressure loss.
Baghouse filtration surface area = 5338 square foot (ft^2) of cloth
Ratio of airflow rate to baghouse filtration surface area = 3.5 cfm : 1 ft^2

During the survey, the design plans for the system to be installed in the new facility were discussed by the ventilation firm's engineer, facility management, and the NIOSH and Battelle survey personnel. The calculated total exhaust rate needed for all the work stations (not including the furnaces and ovens) at the facility is 38,000 cfm. This was to include finishing and welding stations. Since the fan is only capable of 19,000 cfm, the plan was based on the assumption that not all work stations would need full capacity at all times. Local exhaust ventilation use was predicted to be intermittent at all locations and the company planned to use employee training and administrative controls to assure adequate ventilation at the various work stations (see Appendix C for design drawings).

Any excess capacity from this system may be utilized in the Melt Area. At the time of the survey, the ventilation engineer was recommending high-flow fume extractors for the welders as well as the furnaces in the Melt Area. Design parameters for these had not been finalized. See Appendix D for product literature. Ventilation hoods similar to the furnace hood at the old facility were also being considered for the new facility. The hood design and installation in the old facility is relatively new. The design concept originated with a new engineer on staff with the company, who was also accountable for the company's health and safety programs.

A brief visit was made to the old facility to observe this design. The system appeared to work very well. Ventilation measurements are provided in Table 2-2. A schematic of the hood can be found in Figure 2. See Appendix E for the associated baghouse and fan specifications. It is not known whether this design approach would be practical for the new facility since it has more furnaces and the workers were observed to gain access to these furnaces from all sides in the performance of their jobs. Access in the old facility was primarily from both sides and the front but not the back. The contract design engineer felt similar hoods in the new facility might create access problems.

Table 2-2.
Ventilation measurements for furnace hood at the old facility.

Location	Cross-sectional area of face (ft^2)	Average face air velocity (ft/min)	Estimated volumetric air-flow rate (cfm)
Open round duct face	1.4	1300*	1800
Canopy face	28	45	1300

* This measurement was made just after metal had been added to the furnace, which temporarily reduced the temperature above the furnace and allowed the measurement to be made.

In addition to the face-velocity measurements, "smoke tubes" were used to visually evaluate air-flow patterns and capture effectiveness in and around the furnace. The hood was observed to be very effective. There was some loss of capture performance when the furnace was tilted forward to fill the transfer ladle. Overall capture efficiency was very good. There was no local ventilation at the carts where pouring was performed. There were two roof fans which were not operating during the survey and their use seemed to be unfamiliar to personnel. Thermal convection carried vapor and fume upward, in a manner similar to that observed in the new facility, but the accumulation of air contaminants appeared to be less than at the new facility.

B. GENERAL DILUTION EXHAUST VENTILATION AND MAKE-UP AIR

1. New Facility

The long axis of the production area was oriented east to west, as shown in Figure 1. There was an overhead door on the west side adjacent to the Melt Area. This door was often opened to cool the area but was always closed or left partially open to prevent rapid cooling of the castings during and immediately after pouring molds. Air velocities were measured at breathing-zone level, at the low-profile cart where castings were poured, and with the door open and with it closed. With the door closed, velocities were approximately 60 fpm. The velocity doubled to 120 fpm when the door was open. These measurements were taken in front of furnace #2 approximately 20 feet from the door. At the farthest end of the Melt Area in front of furnace #5, the approximate air velocity was 65 fpm with the door closed and 115 fpm with it opened.

There were two 22,000-cfm rooftop and two 25,000-cfm wall-mounted propeller fans in the production area. One rooftop fan was located above the ovens. One wall fan was in the Melt Area located just to the north of the overhead door on the west wall. There was also a Robertson roof ventilator at the peak of the roof over the Melt Area. There was no design information available on the Robertson ventilator. It was in place when the facility was purchased and it was reportedly frozen in a single open position. Access was restricted preventing the measurement of air flow associated with these fans and the Robertson ventilator. There was no mechanical make-up air in the production area. There were two pedestal mounted floor fans in use in the Melt Area, one by the easternmost oven and one at the westside of the Melt Area. Locations for these ventilation devices and the smoke tests performed also are shown in Figure 1.

2. Old Facility

There was one roof mounted fan in the Melt Area and one at the edge of the Melt Area. Neither were operating during the survey. There was one roll-up door and two windows along the south wall that were opened during the survey and which reportedly were generally left open to cool the area. There was also a small canopy connected by 12 inches of stiff corrugated ductwork to the outside through the south wall. There was no measurable airflow coming through the ductwork. The floor plan of the Melt Area and the results of smoke tests and velocity measurements are shown in Figure 3.

C. PERSONAL PROTECTIVE EQUIPMENT (PPE)

1. Safety Glasses

All employees wore safety glasses for the majority of the time, and always when working around the furnaces, ovens, or finishing equipment. Those working in the Melt Area wore darkened safety glasses, face shields, or hoods with protective lenses. Welders wore standard welding helmets.

2. Respirators

No respiratory protection was worn in the Melt Areas at either facility. Particulate dust masks with exhalation valves (3M® Model 8511) were worn by some employees in the Finishing Areas but not those who participated in the PBZ air sampling.

3. Gloves, Boots, Aprons, and Other Clothing

Most employees wore company-provided uniforms, either coveralls or pants and shirts. Laundering was provided by the company. Most employees had long-sleeved shirts or coveralls. The Assistant Melter at the new facility wore a short-sleeved tee-shirt. The company provided steel-toed boots. Neither showers nor clothing changes were required.

During pouring operations, those handling the molten metal wore heat-protective aprons and heavy-duty gloves. At the old facility the Assistant Melter wore a full aluminized heat-protective suit with hood, a Nomex® head sock, and heavy-duty heat-protective mitts. At the old facility, the worker performing that job wore only coveralls, heat-protective sleeves, heavy-duty gloves, and an aluminized heat-protective hood.

4. Hearing Protection

Hearing protection, in the form of disposable ear plugs, was available for all employees but rarely was seen in use.

D. SAFETY AND HEALTH TRAINING, SAFETY AND HEALTH PROGRAMS

Facility representatives stated that Hazard Communication training, including the use of Material Safety Data Sheets (MSDSs), is provided to new employees. The training is not specifically directed toward the hazards of hexavalent chromium. The company safety manual is provided to each employee and utilized by the employee's area supervisor for safety training. The manual was under revision during the survey as part of the company's efforts to assure compliance with "ISO 9000" standards. The company participates in a voluntary third-party audit program with other metalworking companies in the state. They also pay to participate in a "safe-at-work" program facilitated by their state's safety and health department in which they can obtain advice from safety and health consultants in the state offices without risk of citation.

The nearest medical clinic is one mile away from the new facility and the nearest hospital is five miles away. The company has not experienced any occupational illnesses known to be related to chromium and therefore report having nothing listed on their OSHA 200 log related to hexavalent chromium.

E. MEDICAL SURVEILLANCE

1. Chromium Or Other Chemical-Specific Surveillance

No pre-placement or ongoing medical surveillance program is currently in place for chromium. The facility does complete annual audiometric testing and has had experience with employee blood-lead testing.

2. Respirators

Users of 3M® dust mask in the finishing area do not undergo a physical examination prior to use.

F. HOUSEKEEPING, CHEMICAL STORAGE AND HYGIENE

Overall housekeeping on the plant floor appeared good. Storage of metals, alloys, and additives was on open metal storage shelves or in containers in and around the Melt Area.

Employees were observed with food and drink on storage cabinets in the Melt Area during operations. A very large, convenient hand washing station with multiple faucets was located at the north side of the production floor. Located in front of this station were two large tables at which employees sat during breaks with food and drink. This area was not enclosed, but instead was open to the work areas.

COSTS RELATED TO HAZARD CONTROL MEASURES

The primary engineering controls in place at the new facility were propeller-blade fans. In the old facility, the exhaust hood over the furnace was the primary control along with two roof-mounted fans. The cost to install the hood was $1,500. At the time of the survey the company had received a bid to install the ventilation system discussed above for the new facility. The capital cost for the pre-owned precipitator, baghouse and fan was $60,000. The estimated cost to install these systems and local exhaust at work stations was $40,000.

Table 2-4.
Electricity costs for melt area ventilation

Equipment	Fan motor power rating (hp)*	Estimated electric power consumption rate, based on 50% load (kW)	Estimated annual time of operation (hours)	Estimated annual electric power consumed (kWH)	Estimated annual electricity cost
Roof fan 22,000 cfm (x2)	3	1.1	2,600	2,900	$150
Wall fan 25,000 cfm (x2)	3	1.1	2,600	2,900	$150
Furnace Hood Exhaust	20	7.5	3,700	28,000	$1,150

* 1 hp = 0.74570 kilowatt (kW)

In order to estimate the cost of electricity associated with the current operating ventilation equipment, the following assumptions were used:

- Under normal operation, an electric motor operates at 50% of full load.
- The old facility operates on average 16 hours per day, 5 days (or 80 hours) per week. The new facility operates 56 hours per week.
- Ventilation equipment is operated during 90% of facility operating hours.
- Cost of electricity is $0.041 per kilowatt-hour (kWH) in old facility and $0.052 in the new facility.

Based on these assumptions, Table 2-4 shows the estimated electricity costs associated with operation of the roof fans in the new facility and the single exhaust hood in the old facility.

Annual costs associated with the purchase of PPE, training, respirator fit testing and audiometric testing of personal protective equipment for both facilities in the year 2000 were as follows: hearing protection, $2,100; respiratory protection, $7,200; and safety glasses, $800.

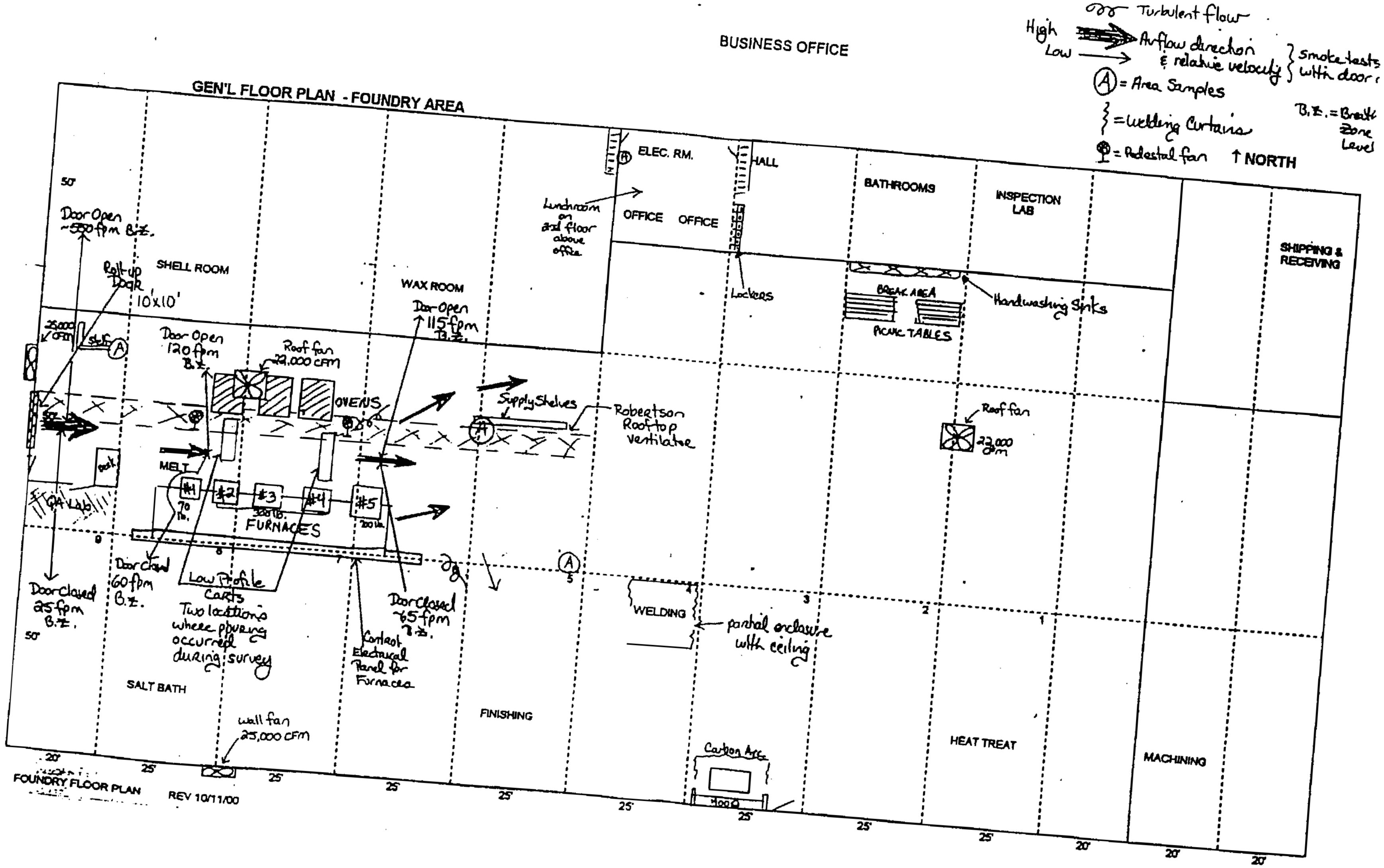
FIGURES

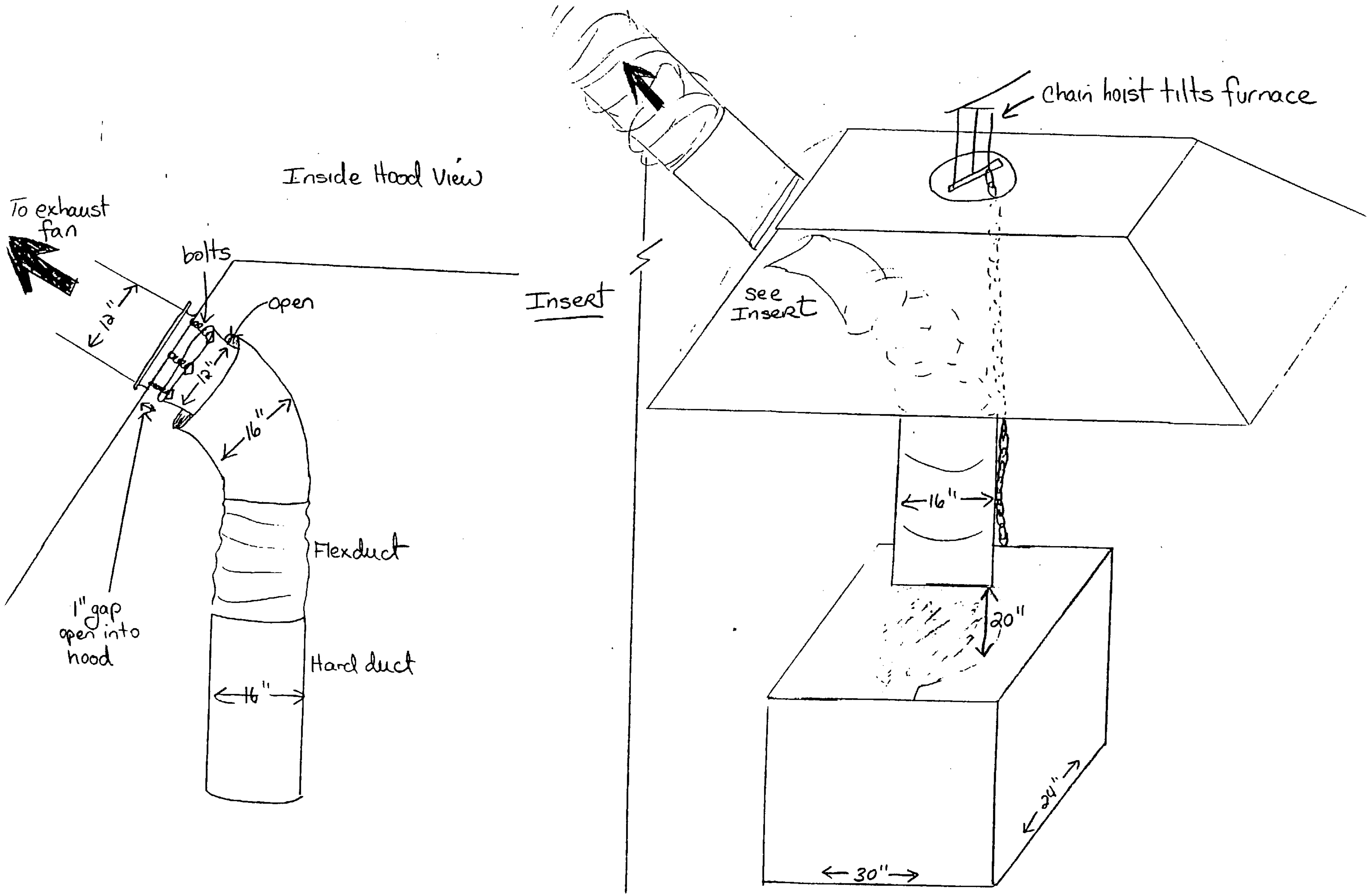
Figure 1. Facility plan

Figure 2. Furnace Hood

Figure 3. Older Facility Melt Area

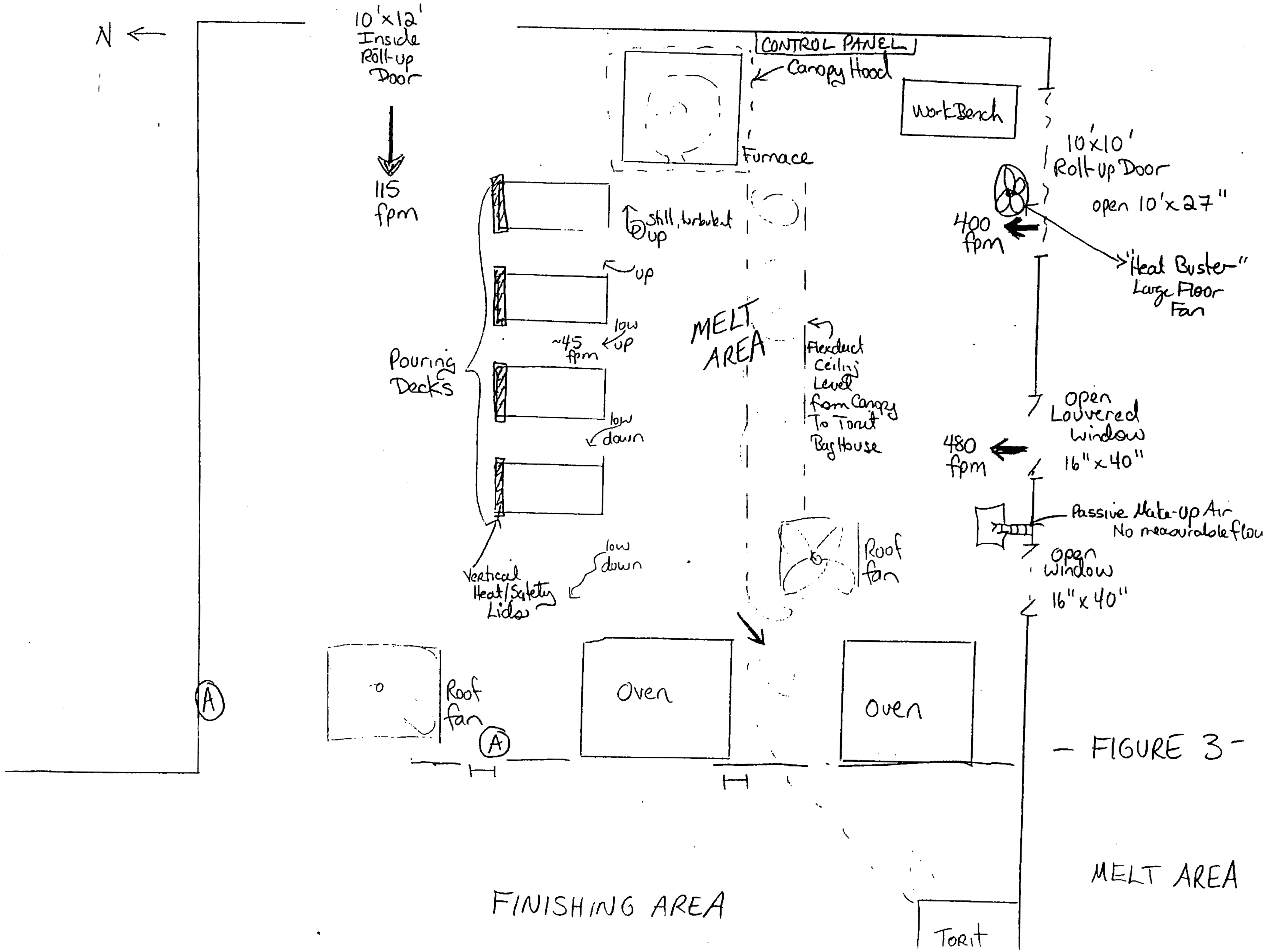
- FIGURE 1 -


BUSINESS OFFICE
Turbulent flow
High
Low
Airflow direction & relative velocity
smoke tests with door
A = Area Samples
= Welding Curtains
= Pedestal fan
↑ NORTH
B.Z. = Breath Zone Level
GEN'L FLOOR PLAN - FOUNDRY AREA
SHELL ROOM
WAX ROOM
ELEC. RM.
HALL
OFFICE
OFFICE
BATHROOMS
INSPECTION LAB
SHIPPING & RECEIVING
Lunchroom on 2nd floor above office
Lockers
BREAK AREA
PICNIC TABLES
Handwashing Sinks
Door Open ~550 fpm B.Z.
Roll-up Dock 10'x10'
25,000 CFM
Door Open 120 fpm B.Z.
Roof fan 22,000 CFM
Door Open 115 fpm B.Z.
OVENS
Supply Shelves
Robertson Rooftop ventilator
Roof fan 23,000 cfm
MELT
FURNACES
Door Closed 25 fpm B.Z.
Door Closed 60 fpm B.Z.
Low Profile Carts
Two locations where pouring occurred during survey
Door Closed ~65 fpm B.Z.
Control Electrical Panel for Furnaces
WELDING
partial enclosure with ceiling
SALT BATH
wall fan 25,000 CFM
FINISHING
Carbon Arc
HEAT TREAT
MACHINING
FOUNDRY FLOOR PLAN
REV 10/11/00



- FIGURE 2 -

FURNACE HOOD


N
10'x12'
Inside
Roll-up
Door
115
fpm
CONTROL PANEL
Canopy Hood
Furnace
Work Bench
10'x10'
Roll-up Door
open 10'x27"
400
fpm
"Heat Buster"
Large Floor
Fan
still, turbulent
up
up
low
up
~45
fpm
low
down
low
down
Pouring
Decks
Vertical
Heat/Safety
Lids
MELT
AREA
Flexduct
Ceiling
Level
from Canopy
To Torit
BagHouse
Open
Louvered
Window
16"x40"
480
fpm
Passive Make-Up Air
No measurable flow
Open
Window
16"x40"
Roof
fan
Roof
fan
A
A
Oven
Oven
FINISHING AREA
MELT AREA
Torit

- FIGURE 3 -

APPENDICES

APPENDIX A – ASTM Specifications, Material Safety Data Sheets (MSDSs) and Spectrometer QA Results

APPENDIX B – American Air Filter Pre-Owned Ventilation Equipment

APPENDIX C – Newer Facility Proposed Ventilation Plans

APPENDIX D – High Flow Fume Extractor

APPENDIX E – Torit Baghouse For Existing Furnace Exhaust System in Older Facility

APPENDIX F – Welding ASTM Specifications Material Safety Data Sheets

APPENDIX A

(46 pages follow)

ASTM Specifications, Material Safety Data Sheets (MSDSs) and Spectrometer QA Results

Sample Ingredients in a Typical Heat

Contents vary depending upon final product.

Low silicon iron (U-Metco scrap metal)
Iron Oxide
Carbon
Nickel
Iron Molybdenum alloy
Zirconium
Vanadium
Iron Pyrite
Iron-Chromium alloy
Electrolytic Manganese
Iron-Silicon
Copper
Iron-Colombium
Carbon riser
Iron-Aluminum

Standard Specification for Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures[1]

This standard is issued under the fixed designation A 732/A732M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers carbon and low-alloy steel castings made by the investment casting process.

1.2 Fifteen grades of steel and two cobalt alloy grades are covered (see Appendix).

NOTE 1—An investment casting is one that is produced in a mold, obtained by investing (surrounding) an expendable pattern with a refractory slurry which is allowed to solidify. The expendable pattern may consist of wax, plastic, or other material and is removed by heating prior to filling the mold with liquid metal.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]

A 488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel[3]

A 919 Terminology Relating to Heat Treatment of Metals[3]

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials[4]

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron[5]

E 94 Guide for Radiographic Testing[6]

E 125 Reference Photographs for Magnetic Particle Indications on Ferrous Castings[6]

E 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials[4]

E 165 Test Method for Liquid Penetrant Examination[6]

E 192 Reference Radiographs of Investment Steel Castings for Aerospace Applications[6]

E 350 Test Methods for Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron[5]

E 446 Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness[6]

E 709 Guide for Magnetic Particle Examination[6]

3. Ordering Information

3.1 Orders for material under this specification should include the following information:

3.1.1 Description of the casting by part or pattern number or drawing,

3.1.2 ASTM designation and year of issue,

3.1.3 Grade of steel,

3.1.4 Quantity,

3.1.5 Options in the specification (4.1, 5.3, 6.1, 9.1, and 10.3), and

3.1.6 Supplementary requirements.

4. Heat Treatment

4.1 Castings shall be supplied in the heat-treated condition with the exception of Grades 21 and 31. Heat treatment shall be either annealing, normalizing and tempering, or quenching and tempering to obtain either the specified properties or other properties that might be agreed upon within each grade. In this latter instance, Supplementary Requirement S19 should be used. Grades 21 and 31 shall be supplied in the as-cast condition unless otherwise agreed upon.

4.2 Heat treatment shall be performed after the castings have been allowed to cool below the transformation range.

4.3 Definitions of terms relating to heat treatment shall be in accordance with Terminology A 919.

5. Chemical Composition

5.1 The castings shall conform to the requirements for chemical composition specified in Table 1 and Table 2.

5.2 *Cast or Heat Analysis*—An analysis of each cast or heat shall be made by the manufacturer to determine the percentages of the elements specified in Table 1 and Table 2. The

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

Current edition approved Sept. 10, 1998. Published October 1998. Originally published as A 732 – 76. Last previous edition A 732/A 732M – 94ε1.

[2] *Annual Book of ASTM Standards*, Vols 01.02 and 01.03.

[3] *Annual Book of ASTM Standards*, Vol 01.02.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

[5] *Annual Book of ASTM Standards*, Vol 03.05.

[6] *Annual Book of ASTM Standards*, Vol 03.03.

TABLE 1 Chemical Requirements

Grade	1A	2A,2Q	3A,3Q	4A,4Q	5N	6N	7Q	8Q
Type	Low Carbon IC 1020[A]	Medium Carbon IC 1030	Medium Carbon IC 1040	Medium Carbon IC 1050	Vanadium IC 6120	Manganese Molybdenum IC 4020	Chromium Molybdenum IC 4130	Chromium Molybdenum IC 4140
Carbon	0.15 to 0.25	0.25 to 0.35	0.35 to 0.45	0.45 to 0.55	0.30 max	0.35 max	0.25 to 0.35	0.35 to 0.45
Manganese	0.20 to 0.60	0.70 to 1.00	0.70 to 1.00	0.70 to 1.00	0.70 to 1.00	1.35 to 1.75	0.40 to 0.70	0.70 to 1.00
Phosphorus, max	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Silicon	0.20 to 1.00	0.20 to 1.00	0.20 to 1.00	0.20 to 1.00	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80
Nickel	...	...	...	...	...	...	...	...
Chromium	...	...	...	...	...	...	0.80 to 1.10	0.80 to 1.10
Molybdenum	...	...	...	...	...	0.25 to 0.55	0.15 to 0.25	0.15 to 0.25
Vanadium	...	...	...	...	0.05 to 0.15	...	...	...
Residual Elements:								
Copper	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nickel	0.50	0.50	0.50	...	0.50	0.50	...	0.50
Chromium	0.35	0.35	0.35	...	0.35	0.35	...	...
Molybdenum + Tungsten	0.25	...	...	...	0.25	...	...	...
Tungsten	...	0.10	0.10	0.10	...	0.25	0.10	0.10
Total content of unspecified elements	1.00	1.00	1.00	0.60	1.00	1.00	0.60	1.00

Grade	9Q	10Q	11Q	12Q	13Q	14Q	15A
Type	Chrome Nickel Molybdenum IC 4330	Chrome Nickel Molybdenum IC 4340	Nickel Molybdenum IC 4620	Chromium Vanadium IC 6150	Chrome Nickel Molybdenum IC 8620	Chrome Nickel Molybdenum IC 8630	Chromium IC 52100
Carbon	0.25 to 0.35	0.35 to 0.45	0.15 to 0.25	0.45 to 0.55	0.15 to 0.25	0.25 to 0.35	0.95 to 1.10
Manganese	0.40 to 0.70	0.70 to 1.00	0.40 to 0.70	0.65 to 0.95	0.65 to 0.95	0.65 to 0.95	0.25 to 0.55
Phosphorus, max	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Silicon	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80	0.20 to 0.80
Nickel	1.65 to 2.00	1.65 to 2.00	1.65 to 2.00	...	0.40 to 0.70	0.40 to 0.70	...
Chromium	0.70 to 0.90	0.70 to 0.90	...	0.80 to 1.10	0.40 to 0.70	0.40 to 0.70	1.30 to 1.60
Molybdenum	0.20 to 0.30	0.20 to 0.30	0.20 to 0.30	...	0.15 to 0.25	0.15 to 0.25	...
Vanadium	...	...	...	0.15 min	...	...	...
Residual Elements:							
Copper	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nickel	...	...	...	0.50	...	...	0.50
Chromium	...	...	0.35	...	...	...	...
Molybdenum + Tungsten	...	...	...	0.10	...	...	...
Tungsten	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total content of unspecified elements	0.60	1.00	1.00	1.00	1.00	1.00	0.60

[A] Investment Casting (IC) numbers are to be used only for nomenclature comparison.

TABLE 2 Chemical Requirements

Type	Grade 21	Grade 31
Carbon	0.20–0.30	0.45–0.55
Manganese	1.00 max	1.00 max
Silicon, max	1.00	1.00
Phosphorus, max	0.040	0.040
Sulfur, max	0.040	0.040
Chromium	25.00–29.00	24.50–26.50
Nickel	1.75–3.75	9.50–11.50
Cobalt	remainder	remainder
Molybdenum	5.00–6.00	. . .
Tungsten	. . .	7.00–8.00
Vanadium	. . .	. . .
Columbium + tantalum	. . .	. . .
Nitrogen	. . .	. . .
Iron	3.00 max	2.00 max
Boron	0.007 max	0.005–0.015

analysis shall be made from a test sample taken preferably during the pouring of the heat, or from a master heat (Note 2) which is remelted with only minor additions for deoxidization. The chemical composition determined from the heat or master heat shall be reported to the purchaser, or his representative, and shall conform to the requirements in Table 1.

NOTE 2—A master heat is refined and alloyed metal of a single furnace charge, not exceeding 10 000 lb [4500 kg].

5.3 *Product-Check-Verification Analysis*—A product analysis may be made by the purchaser from material representing each heat, lot, or casting. The analysis shall be made on representative material. Due to the possibility of decarburization, carbon and alloy steel samples for carbon analysis shall be taken no closer than ¼ in. [6.4 mm] to a cast surface except that castings too thin for this shall be analyzed on representative material. The chemical composi-tion thus determined shall meet the requirements specified in Table 1 and Table 2.

5.4 *Referee Analysis*—Test Methods E 30 and E 350 shall be used for reference purposes. When a comparison is made between the heat analysis and product analysis, the reproducibility data, R_2, in the precision statement of Test Methods E 350 shall be used as a guide.

6. Workmanship, Finish, and Appearance

6.1 The castings shall conform substantially to the shapes and sizes indicated by the patterns and drawings submitted by the purchaser. Casting tolerances or deviations from drawing dimensions shall be agreed upon between the purchaser and the

Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application[1]

This standard is issued under the fixed designation A 743/A 743M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers iron-chromium and iron-chromium-nickel alloy castings for general corrosion-resistant application. The grades covered by this specification represent types of alloy castings suitable for broad ranges of application which are intended for a wide variety of corrosion environments.

NOTE 1—For alloy castings for severe corrosion-resistant service, reference should be made to Specification A 744/A 744M. For general heat-resistant alloy castings, reference should be made to Specification A 297/A 297M. For nickel alloy castings for corrosion-resistant service, reference should be made to Specification A 494/A 494M.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. Inch-pound units are applicable for material ordered to Specification A 743 and SI units for material ordered to Specification A 743M.

2. Referenced Documents

2.1 *ASTM Standards:*

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels[2]

A 297/A297M Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat-Resistant, for General Application[3]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[2]

A 447/A447M Specification for Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service[3]

A 494/A494M Specification for Castings, Nickel and Nickel Alloy[3]

A 744/A744M Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service[3]

A 781/A781M Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use[3]

3. General Conditions for Delivery

3.1 Material furnished to this specification shall conform to the requirements of Specification A 781/A 781M, including any supplementary requirements that are indicated on the purchase order. Failure to comply with the general requirements of Specification A 781/A 781M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 781/A 781M, this specification shall prevail.

4. Ordering Information

4.1 Orders for material to this specification should include the following, as required, to describe the material adequately:

4.1.1 Description of the casting by pattern number or drawing,

4.1.2 Grade,

4.1.3 Heat treatment,

4.1.4 Options in the specification, and

4.1.5 Supplementary requirements desired, including the standards of acceptance.

5. Process

5.1 The steel shall be made by the electric furnace process with or without separate refining such as argon-oxygen decarburization (AOD).

6. Heat Treatment

6.1 Castings shall be heat treated in accordance with the requirements in Table 1.

NOTE 2—Proper heat treatment of these alloys is usually necessary to enhance corrosion resistance and in some cases to meet mechanical properties. Minimum heat treat temperatures are specified; however, it is sometimes necessary to heat treat at higher temperatures, hold for some minimum time at temperature and then rapidly cool the castings in order to enhance the corrosion resistance and meet mechanical properties.

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

Current edition approved May 10, 1998. Published November 1998. Originally published as A 743 – 77. Last previous edition A 743/A 743M – 95[ε1].

[2] *Annual Book of ASTM Standards*, Vol 01.03.

[3] *Annual Book of ASTM Standards*, Vol 01.02.

TABLE 1 Heat Treatment Requirements

Grade	Heat Treatment
CF-8, CG-3M (J92999), CG-8M, CG-12, CF-20, CF-8M, CF-8C,CF-16F, CF-16Fa	Heat to 1900°F [1040°C] minimum, hold for sufficient time to heat casting to temperature, quench in water or rap[illegible] cool by other means.
CH-10, CH-20, CE-30, CK-20	Heat to 2000°F [1093°C] minimum, hold for sufficient time to heat casting to temperature, quench in water or rap[illegible] cool by other means.
CA-15, CA-15M, CA-40, CA-40F	(*1*) Heat to 1750°F [955°C] minimum, air cool and temper at 1100°F [595°C] minimum, or (*2*) Anneal at 1450°F [790°C] minimum.
CB-30, CC-50	(*1*) Heat to 1450°F [790°C] minimum, and air cool, or (*2*) Heat to 1450°F [790°C] minimum, and furnace cool.
CF-3, CF-3M, CF-3MN	(*1*) Heat to 1900°F [1040°C] minimum, hold for sufficient time to heat casting to temperature, and cool rapidly. (*2*[illegible] As cast if corrosion resistance is acceptable.
CN-3M (J94652)	Heat to 2150°F [1175°C] minimum, hold for sufficient time to heat casting to temperature, quench in water or rap[illegible] cool by other means.
CN-3MN	Heat to 2100°F [1150°C] minimum, hold for sufficient time to heat casting to temperature, quench in water or rap[illegible] cool by other means.
CN-7M, CG-6MMN	Heat to 2050°F [1120°C] minimum, hold for sufficient time to heat casting to temperature, quench in water or rap[illegible] cool by other means.
CN-7MS	Heat to 2100°F [1150°C] minimum, 2150°F [1180°C] maximum, hold for sufficient time (2 h minimum) to heat casting to temperature and quench in water.
CA-6NM	Heat to 1850°F [1010°C] minimum, air cool to 200°F [95°C] or lower prior to any optional intermediate temper[illegible] prior to the final temper. The final temper shall be between 1050°F [565°C] and 1150°F [620°C].
CA-6N (J91541)	Heat to 1900°F [1040°C], air cool, reheat to 1500°F [815°C], air cool, and age at 800°F [425°C], holding at ea[illegible] temperature sufficient time to heat casting uniformly to temperature.
CF10SMnN	Heat to 1950°F [1065°C] minimum, hold for sufficient time to heat casting to temperature, quench in water o[illegible] cool by other means.
CA-28MWV	(*1*) Heat to 1875–1925°F [1025–1050°C], quench in air or oil, and temper at 1150°F [620°C] minimum, or (*2*) Anneal at 1400°F [760°C] minimum.
CK-3MCuN	Heat to 2100°F [1150°C] minimum, hold for sufficient time to heat casting to temperature, quench in water or [illegible] cool by other means.
CK-35MN	Heat to 2100-2190F [1150-1200C], hold for sufficient time to heat casting to temperature, quench in water or [illegible] cool by other means.
CB-6 (J91804)	Heat between 1800°F [980°C] and 1920°F [1050°C], forced air, cool to 120°F [50°C] maximum, and temper [illegible] between 1100°F and 1160°F [595°C and 625°C].

TABLE 2 Chemical Requirements

NOTE 1—CD-4MCu has been deleted from A 743/A 743M and added to A 890/A 890M. CD-4MCu may now be supplied and purchased in comp[illegible] with A 890/A 890M. The chemical and mechanical property requirements of CD-4MCu were identical in A 743/A 743M and A 890/A 890M at the [illegible] of removal from A 743/A 743M.

Grade	Type	Composition, %												
		Carbon, max	Manganese, max	Silicon, max	Phosphorus, max	Sulfur, max	Chromium	Nickel	Molybdenum	Columbium	Selenium	Copper	Tungsten, max	Vanadium, max
CF-8	19 Chromium, 9 Nickel	0.08	1.50	2.00	0.04	0.04	18.0–21.0	8.0–11.0	...	...	...	...	...	...
CG-12	22 Chromium, 12 Nickel	0.12	1.50	2.00	0.04	0.04	20.0–23.0	10.0–13.0	...	...	...	...	...	...
CF-20	19 Chromium, 9 Nickel	0.20	1.50	2.00	0.04	0.04	18.0–21.0	8.0–11.0	...	...	...	...	...	...
CF-8M	19 Chromium, 10 Nickel, with Molybdenum	0.08	1.50	2.00	0.04	0.04	18.0–21.0	9.0–12.0	2.0–3.0	...	...	...	...	...
CF-8C	19 Chromium, 10 Nickel, with Columbium	0.08	1.50	2.00	0.04	0.04	18.0–21.0	9.0–12.0	...	A	...	...	...	...
CF-16F	19 Chromium, 9 Nickel, Free Machining	0.16	1.50	2.00	0.17	0.04	18.0–21.0	9.0–12.0	1.50 max	...	0.20–0.35	...	...	...
CF-16Fa	19 Chromium, 9 Nickel, Free Machining	0.16	1.50	2.00	0.04	0.20–0.40	18.0–21.0	9.0–12.0	0.40–0.80	...	...	...	...	...
CH-10	25 Chromium, 12 Nickel	0.10	1.50	2.00	0.04	0.04	22.0–26.0	12.0–15.0	...	...	...	...	...	...
CH-20	25 Chromium, 12 Nickel	0.20	1.50	2.00	0.04	0.04	22.0–26.0	12.0–15.0	...	...	...	...	...	...
CK-20	25 Chromium, 20 Nickel	0.20	2.00	2.00	0.04	0.04	23.0–27.0	19.0–22.0	...	...	...	...	...	...
CE-30	29 Chromium, 9 Nickel	0.30	1.50	2.00	0.04	0.04	26.0–30.0	8.0–11.0	...	...	...	...	...	...
CA-15	12 Chromium	0.15	1.00	1.50	0.04	0.04	11.5–14.0	1.00 max	0.50 max	...	...	...	...	...

TABLE 2 *Continued*

Grade	Type	Composition, %													
		Carbon, max	Manganese, max	Silicon, max	Phosphorus, max	Sulfur, max	Chromium	Nickel	Molybdenum	Columbium	Selenium	Copper	Tungsten, max	Vanadium, max	Nitrogen
CA-15M	12 Chromium	0.15	1.00	0.65	0.040	0.040	11.5–14.0	1.0 max	0.15–1.0	...	...	...	...	...	...
CB-30	20 Chromium	0.30	1.00	1.50	0.04	0.04	18.0–21.0	2.00 max	...	...	...	B	...	...	...
CC-50	28 Chromium	0.50	1.00	1.50	0.04	0.04	26.0–30.0	4.00 max	...	...	...	...	...	...	...
CA-40	12 Chromium	0.20–0.40	1.00	1.50	0.04	0.04	11.5–14.0	1.0 max	0.5 max	...	...	...	...	...	...
CA-40F	12 Chromium, Free Machining	0.20–0.40	1.00	1.50	0.04	0.20–0.40	11.5–14.0	1.0 max	0.5 max	...	...	...	...	...	...
CF-3	19 Chromium, 9 Nickel	0.03	1.50	2.00	0.04	0.04	17.0–21.0	8.0–12.0	...	...	...	...	...	...	...
CF10SMnN	17 Chromium, 8.5 Nickel with Nitrogen	0.10	7.00–9.00	3.50–4.50	0.060	0.030	16.0–18.0	8.0–9.0	...	...	...	...	...	...	0.08–0.18
CF-3M	19 Chromium, 10 Nickel, with Molybdenum	0.03	1.50	1.50	0.04	0.04	17.0–21.0	9.0–13.0	2.0–3.0	...	...	...	...	...	...
CF-3MN	19 Chromium, 10 Nickel, with Molybdenum, and Nitrogen	0.03	1.50	1.50	0.040	0.040	17.0–22.0	9.0–13.0	2.0–3.0	...	...	...	...	...	0.10–0.20
CG6MMN		0.06	4.00–6.00	1.00	0.04	0.03	20.5–23.5	11.5–13.5	1.50–3.00	0.10–0.30	...	...	...	0.10–0.30	0.20–0.40
CG-3M (J92999)	19 Chromium, 11 Nickel, with Molybdenum	0.03	1.50	1.50	0.04	0.04	18.0–21.0	9.0–13.0	3.0–4.0	...	...	...	...	...	...
CG-8M	19 Chromium, 11 Nickel, with Molybdenum	0.08	1.50	1.50	0.04	0.04	18.0–21.0	9.0–13.0	3.0–4.0	...	...	...	...	...	...
CN-3M (J94652)		0.03	2.0	1.0	0.03	0.03	20.0–22.0	23.0–27.0	4.5–5.5	...	...	...	...	...	...
CN-3MN	21 Chromium, 24 Nickel with Molybdenum and Nitrogen	0.03	2.00	1.00	0.040	0.010	20.0–22.0	23.5–25.5	6.0–7.0	...	...	0.75 max	...	...	0.18–0.26
CN-7M	20 Chromium, 29 Nickel, with Copper and Molybdenum	0.07	1.50	1.50	0.04	0.04	19.0–22.0	27.5–30.5	2.0–3.0	...	...	3.0–4.0	...	...	...
CN-7MS	19 Chromium, 24 Nickel, with Copper and Molybdenum	0.07	1.00	2.50–3.50	0.04	0.03	18.0–20.0	22.0–25.0	2.5–3.0	...	...	1.5–2.0	...		
CA-6NM	12 Chromium, 4 Nickel	0.06	1.00	1.00	0.04	0.03	11.5–14.0	3.5–4.5	0.40–1.0	...	...	...	...	...	...
CA6N	11 Chromium, 7 Nickel	0.06	0.50	1.00	0.02	0.02	10.5–12.5	6.0–8.0	...	...	...	...	...	...	...
CA-28MWV	12 Chromium, with Molybdenum, Tungsten and Vanadium	0.20–0.28	0.50–1.00	1.0	0.030	0.030	11.0–12.5	0.50–1.00	0.90–1.25	...	...	...	0.90–1.25	0.20–0.30	...
CK-3MCuN	20 Chromium 18 Nickel, with Copper and Molybdenum	0.025	1.20	1.00	0.045	0.010	19.5–20.5	17.5–19.5	6.0–7.0	...	...	0.50–1.00	...	...	0.180–0.240
CK-35MN	23 Chromium, 21 Nickel, with Molybdenum and Nitrogen	0.035	2.00	1.00	0.035	0.020	22.0–24.0	20.0-22.0	6.0-6.8	...	...	0.40	...	...	0.21-0.32
CB-6 (J91804)	16 Chromium, 4 Nickel	0.06	1.00	1.00	0.04	0.03	15.5–17.5	3.5–5.5	0.5 max	...	...	...	...	...	...

[A] Grade CF-8C shall have a columbium content of not less than eight times the carbon content and not more than 1.0%. If a columbium-plus-tantalum alloy in the approximate Cb:Ta ratio of 3:1 is used for stabilizing this grade, the total columbium-plus-tantalum content shall not be less than nine times the carbon content and shall not exceed 1.1%.

[B] For Grade CB-30 a copper content of 0.90 to 1.20% is optional.

Endorsed by Manufacturers Standardization Society
of the Valve and Fittings Industry
Endorsed by American Foundrymen's Society
Used in USDOE-NE Standards
An American National Standard

Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service[1]

This standard is issued under the fixed designation A 216/A216M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification[2] covers carbon steel castings for valves, flanges, fittings, or other pressure-containing parts for high-temperature service and of quality suitable for assembly with other castings or wrought-steel parts by fusion welding.

1.2 Three grades, WCA, WCB, and WCC, are covered in this specification. Selection will depend upon design and service conditions, mechanical properties, and the high temperature characteristics.

1.3 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 488/A488M Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel[3]

A 703/A703M Specification for Steel Castings, General Requirements, for Pressure-Containing Parts[3]

E 165 Test Method for Liquid Penetrant Examination[4]

E 709 Guide for Magnetic Particle Examination[4]

2.2 *Manufacturers' Standardization Society of the Valve and Fittings Industry Standard:*

SP 55 Steel Castings for Valve, Flanges, and Fittings, and Other Components (Visual Method)[5]

3. General Conditions for Delivery

3.1 Material furnished to this specification shall conform to the requirements of Specification A 703/A 703M, including any supplementary requirements that are indicated in the purchase order. Failure to comply with the general requirements of Specification A 703/A 703M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 703/A 703M, this specification shall prevail.

4. Ordering Information

4.1 The inquiry and order should include or indicate the following:

4.1.1 A description of the casting by pattern number or drawing (dimensional tolerances shall be included on the casting drawing),

4.1.2 Grade of steel,

4.1.3 Options in the specification, and

4.1.4 The supplementary requirements desired including the standards of acceptance.

5. Heat Treatment

5.1 All castings shall receive a heat treatment proper to their design and chemical composition.

5.2 Castings shall be furnished in the annealed, or normalized, or normalized and tempered condition unless Supplementary Requirement S15 is specified.

5.3 Heat treatment shall be performed after castings have been allowed to cool below the transformation range.

6. Temperature Control

6.1 Furnace temperatures for heat treating shall be effectively controlled by pyrometer.

7. Chemical Composition

7.1 The steel shall conform to the requirements as to chemical composition prescribed in Table 1.

[1] This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

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[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-216/SA-216M in Section II of that code.

[3] *Annual Book of ASTM Standards*, Vol 01.02.

[4] *Annual Book of ASTM Standards*, Vol 03.03.

[5] Available from Manufacturers' Standardization Society of the Valve and Fittings Industry, 127 Park St., N.E. Vienna, VA 22180.

TABLE 1 Chemical Requirements

Element	Composition, %		
	Grade WCA	Grade WCB	Grade WCC
Carbon, max	0.25[A]	0.30[B]	0.25[C]
Manganese, max	0.70[A]	1.00[B]	1.20[C]
Phosphorus, max	0.04	0.04	0.04
Sulfur, max	0.045	0.045	0.045
Silicon, max	0.60	0.60	0.60
Specified residual elements:			
Copper, max	0.30	0.30	0.30
Nickel, max	0.50	0.50	0.50
Chromium, max	0.50	0.50	0.50
Molybdenum, max	0.20	0.20	0.20
Vanadium, max	0.03	0.03	0.03
Total of these specified residual elements, max[D]	1.00	1.00	1.00

[A]For each reduction of 0.01 % below the specified maximum carbon content, an increase of 0.04 % manganese above the specified maximum will be permitted up to a maximum of 1.10 %.

[B]For each reduction of 0.01 % below the specified maximum carbon content, an increase of 0.04 % Mn above the specified maximum will be permitted up to a maximum of 1.28 %.

[C]For each reduction of 0.01 % below the specified maximum carbon content, an increase of 0.04 % manganese above the specified maximum will be permitted to a maximum of 1.40 %.

[D]Not applicable when Supplementary Requirement S11 is specified.

8. Tensile Requirements

8.1 Steel used for the castings shall conform to the requirements as to tensile properties prescribed in Table 2.

9. Quality

9.1 The surface of the casting shall be examined visually and shall be free of adhering sand, scale, cracks, and hot tears. Other surface discontinuities shall meet the visual acceptance standards specified in the order. Visual Method SP-55 or other visual standards may be used to define acceptable surface discontinuities and finish. Unacceptable visual surface discontinuities shall be removed and their removal verified by visual examination of the resultant cavities.

9.2 When additional inspection is desired, Supplementary Requirements S4, S5, and S10 may be ordered.

9.3 The castings shall not be peened, plugged, or impregnated to stop leaks.

TABLE 2 Tensile Requirements

	Grade WCA	Grade WCB	Grade WCC
Tensile strength, ksi [MPa]	60 to 85 [415 to 585]	70 to 95 [485 to 655]	70 to 95 [485 to 655]
Yield strength,[A] min, ksi [MPa]	30 [205]	36 [250]	40 [275]
Elongation in 2 in. [50 mm], min, %[B]	24	22	22
Reduction of area, min, %	35	35	35

[A]Determine by either 0.2 % offset method or 0.5 % extension-under-load method.

[B]When ICI test bars are used in tensile testing as provided for in Specification A 703/A 703M, the gage length to reduced section diameter ratio shall be 4 to 1.

10. Repair by Welding

10.1 Repairs shall be made using procedures and welders qualified under Practice A 488/A 488M.

10.2 Weld repairs shall be inspected to the same quality standards that are used to inspect the castings. When castings are produced with Supplementary Requirement S4 specified, weld repairs shall be inspected by magnetic particle examination to the same standards that are used to inspect the castings. When castings are produced with Supplementary Requirement S5 specified, weld repairs on castings that have leaked on hydrostatic test, or on castings in which the depth of any cavity prepared for repair welding exceeds 20 % of the wall thickness or 1 in. [25 mm], whichever is smaller, or on castings in which any cavity prepared for welding is greater than approximately 10 in.^{2}[65 cm^2], shall be radiographed to the same standards that are used to inspect the castings.

10.3 Castings containing any repair weld that exceeds 20 % of the wall thickness or 1 in. [25 mm], whichever is smaller, or that exceeds approximately 10 in.^{2}[65 cm^2] in area, or that was made to correct hydrostatic test defects, shall be stress relieved or heat-treated after welding. This mandatory stress relief or heat-treatment shall be in accordance with the procedure qualification used.

11. Keywords

11.1 carbon steel; high temperature; pressure containing parts; steel castings

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall not apply unless specified in the purchase order. A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification A 703/A 703M. Those which are ordinarily considered suitable for use with this specification are given below. Others enumerated in A 703/A 703M may be used with this specification upon agreement between the manufacturer and purchaser.

DAILY MELT LOG

NUMBER OF HEATS PER CRUCIBLE		Red Pot	Blue Pot	Other:
	START OF DAY	24		
	HEATS POURED TODAY			
	END OF DAY			

PAGE 1 OF ____

PRIMARY # OTD

DATE: 0 0 1 0 1 3 (Y Y M M D D)

warm

before SAM

after SAM

cold

Heat#	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
1		Flats	4130	8		350	0	350

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
50	350	444	0	0	0	250	140	3050	1980		NT

Red Pot ✓ Blue Pot

Chemistry: OK ☐ Poor ☐

Comments:

4130 R

Heat#	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
2		Flats	4130	8		350	0	350

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
50	350	444	0	0	0	250	140	3050	1900		NT

Red Pot ✓ Blue Pot

Chemistry: OK ☐ Poor ☐

Comments:

Heat#	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
3		flats	4130	8		350	0	350

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
50	350	444	0	0	0	250	140	3050	1900		NT

Red Pot ✓ Blue Pot

Chemistry: OK ☐ Poor ☐

Comments:

Carbon

Heat#	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
4		Flats	4130	8		0	350	350

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
100	350	1550	0	126	123	250	140	3050	1900		NT

Red Pot ✓ Blue Pot

Chemistry: OK ☐ Poor ☐

Comments:

0.80-1.10% C

4130 CHIPS

Heat#	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
5		flats	4130	8		0	350	350

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
100	350	1550	0	126	123	250	140	3040	1900		NT

Red Pot ✓ Blue Pot

Chemistry: OK ☐ Poor ☐

Comments:

(0.8-1.1% C)

DAILY MELT LOG

PAGE ____ OF ____

PRIMARY # 0TD

Heat #	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
		flats	4130	8		0	350	350

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
~~100~~ 100	350	1550	0	126	123	250	144	3050	1900		NT

Red Pot [X] Blue Pot [ ]
Chemistry: OK [ ] Poor [ ]
Comments:
0.80-1.10% Cr
4170 CHIPs

Heat #	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb
		oil ring	17-4			360	0	360

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT
0	0	200	0	250	0	260	144	2000	1800		NT

Red Pot [X] Blue Pot [ ]
Chemistry: OK [ ] Poor [ ]
Comments:
17-4 R 15.5-16.7 Cr

Heat #	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT

Red Pot [ ] Blue Pot [ ]
Chemistry: OK [ ] Poor [ ]
Comments:

Heat #	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT

Red Pot [ ] Blue Pot [ ]
Chemistry: OK [ ] Poor [ ]
Comments:

Heat #	SCID #	Part Name	Alloy	# Trees	Prime Lb	Revert Lb	Chips Lb	Total Lb

C	Mn	Si	Ni	Cr	Mo	Stel	Al	Pour °F	Oven °F	Mold °F	INIT

Red Pot [ ] Blue Pot [ ]
Chemistry: OK [ ] Poor [ ]
Comments:

Sellie

PPT. Hardening Stainless Steels

Greenville Metals.

Alloy	Specification	Carbon Min—Max	Manganese Min—Max	Silicon Min—Max	Chromium Min—Max	Nickel Min—Max	Molybdenum Min—Max	Phosphorus Min—Max	Sulfur Min—Max	Copper Min—Max	Iron	Other	Melting Range °F
14-4	AMS 5340B	.06	.70	.50-1.00	13.50-14.25	3.75-4.75	2.0 -2.50	.020	.025	3.00-3.50	Bal.	Cb/Ta. .15-.35; N_2, .05 Max.	25[illegible]
15-5	AMS 5346, 5347, 5356, 5357, 5400	.05	.50	.50-1.00	14.00-15.50	4.20-5.00		.025	.025	2.50-3.20	Bal.	Cb/Ta. .15-.30; N_2, .05 Max.	2560[illegible]
	ASTM A-747 CB 7 Cu-2 ACI-CB-7 Cu-2	.07	.70	1.00	14.0 -15.50	4.50-5.50		.035	.03	2.50-3.20	Bal.	Cb/Ta. .15-.55; N_2, .05 Max.	2560-2[illegible]
	IC 15-5-PH	.05	.50	.50-1.00	14.00-15.50	4.20-5.00		.025	.025	2.50-3.20	Bal.	Cb/Ta. .15-.30; N_2, .05 Max.	2560-262[illegible]
17-4	AMS 5342B, 5343B, 5344B	.06	.70	.50-1.00	15.5 -16.7	3.60-4.60		.025	.025	2.8 -3.5	Bal.	Cb/Ta. .15-.40; Al. .05 Max.; N_2, .05 Max.; Sn. .02 Max.	2560-2625
	AMS 5355D	.06	.70	.50-1.00	15.5 -16.7	3.60-4.60		.04	.03	2.8 -3.5	Bal.	Cb/Ta. .15-.40; Al. .05 Max.; N_2, .05 Max.; Sn. .02 Max.	2560-2625
	(ARMCO)	.07	1.00	1.00	15.5 -17.5	3.00-5.00		.04	.03	3.0 -5.0	Bal.	Cb/Ta. .25-.45	2560-2625
	IC 17-4PH	.06	.70	.50-1.00	15.5 -16.7	3.60-4.60		.04	.03	2.8 -3.5	Bal.	Cb/Ta. .15-.40; N_2, .05 Max.	2560-2625
	ASTM A-747 CB 7 Cu-1	.07	.70	1.00	15.5 -17.7	3.60-4.60		.035	.03	2.50-3.20	Bal.	Cb. .15-.35; N_2, .05 Max.	2560-262[illegible]

Alloy	Specification	Carbon Min—Max	Manganese Min—Max	Silicon Min—Max	Chromium Min—Max	Nickel Min—Max	Molybdenum Min—Max	Phosphorus Min—Max	Sulfur Min—Max	Iron	Other	Melting Range °F
304	AMS 5370B, AMS 5317C	.05	1.00-2.00	0.75-1.50	18.0 -21.0	8.0 -11.0	.75	.04	.04	Bal.	Cu. .75 Max.	2550-2650
	MIL-S-81591 IC 304	.08	2.00	1.00	18.0 -20.0	8.0 -12.0		.04	.03	Bal.		2550-2650
	MIL-S-81591 IC 304L	.05	1.00-2.00	1.00	18.0 -21.0	8.0 -11.0	.50	.04	.03	Bal.	Cu. .50 Max.	2550-2650
	MIL-S-867A CL1	.08	1.50	2.00	18.0 -21.0	8.0 -11.0		.05	.05	Bal.		2550-2650
	MIL-S-18262A CL1	.08	1.50	2.00	18.0 -21.0	8.0		.045	.045	Bal.	Co. .20 Max.	2550-2650
	ASTM A-743 GR CF3, ASTM A-744 GR CF3	.03	1.50	2.00	17.0 -21.0	8.0 -12.0		.04	.04	Bal.		2550-2650
	ASTM A-743 GR CF8, ASTM A-744 GR CF8	.08	1.50	2.00	18.0 -21.0	8.0 -11.0		.04	.04	Bal.		2550-2650
	ASTM A-351 GR CF3, CF3A	.03	1.50	2.00	17.0 -21.0	8.0 -12.0	.50	.04	.04	Bal.		2550-2650
	ASTM A-351 GR CF8, CF8A	.08	1.50	2.00	18.0 -21.0	8.0 -11.0	.50	.04	.04	Bal.		2550-2650
	ACI-CF8	.08	1.50	2.00	18.0 -21.0	8.0 -11.0		.04	.04	Bal.		2550-2650
	IC CF-3	.03	1.50	2.00	17.0 -21.0	8.0 -12.0		.04	.04	Bal.		2550-2650
	IC CF-8	.08	1.50	2.00	18.0 -21.0	8.0 -11.0		.04	.04	Bal.		2550-2650
	SAE 30304L	.03	2.00	1.00	18.0 -20.0	8.0 -12.0		.045	.03	Bal.		2550-2650
	SAE 30304	.08	2.00	1.00	18.0 -20.0	8.0 -10.5		.045	.03	Bal.		2550-2650
	ASTM A-351 GR CF 10	.04- .10	1.50	2.00	18.0 -21.0	8.0 -11.0	.50	.04	.04	Bal.		2550-2650

Alloy	Specification	Carbon Min—Max	Manganese Min—Max	Silicon Min—Max	Chromium Min—Max	Nickel Min—Max	Molybdenum Min—Max	Phosphorus Min—Max	Sulfur Min—Max	Iron	Other	Melting Range °F
311	ASTM A-297 GR HN, ACI HN, SAE 70311	.20- .50	2.00	2.00	19.0 -23.0	23.0 -27.0	.50	.04	.04	Bal.		2500-2600
312	ASTM A-743 GR CE30	.30	1.50	2.00	26.0 -30.0	8.0 -11.0		.04	.04	Bal.		2600-2700
	ASTM A-297 GR HE	.20- .50	2.00	2.00	26.0 -30.0	8.0 -11.0	.50	.04	.04	Bal.		2600-2700
316	AMS 5360D	.15	2.00	.75	16.0 -18.0	12.0 -14.0	1.50-2.25	.04	.03	Bal.	Cu. .75 Max.	2500-2550
	AMS 5361D	.15- .25	2.00	1.00	17.0 -20.0	12.0 -15.0	1.75-2.50	.04	.04	Bal.	Cu. .75 Max.	2500-2550
	MIL-S-867A CL III	.08	1.50	2.0	18.0 -21.0	9.0 -12.0	2.00-3.00	.05	.05	Bal.		2500-2550
	MIL-S-81591 IC316	.08	2.0	1.0	16.0 -18.0	10.0 -14.0	2.00-3.00	.04	.0[illegible]	Bal.		2500-2550
	ASTM A-351 GR CF3M, CF3MA	.03	1.50	1.50	17.0 -21.0	9.0 -13.0	2.00-3.00	.04	.04	Bal.		2500-2550
	ASTM A-743 GR CF3M, ASTM A-744 GR CF3M	.03	1.50	1.50	17.0 -21.0	9.0 -13.0	2.00-3.00	.04	.04	Bal.		2500-2550
	ASTM A-743 GR CF8M, ASTM A-744 GR CF8M	.08	1.50	2.00	18.0 -21.0	9.0 -12.0	2.00-3.00	.04	.04	Bal.		2500-2550
	ASTM A-351 GR CF8M	.08	1.50	1.50	18.0 -21.0	9.0 -12.0	2.00-3.00	.04	.04	Bal.		2500-2550
	ACI CF3M	.03	1.50	1.50	17.0 -21.0	9.0 -13.0	2.00-3.00	.04	.04	Bal.		2500-2550
	IC CF3M	.03	1.50	1.50	17.0 -21.0	9.0 -13.0	2.00-3.00	.04	.04	Bal.		2500-2550
	ACI CF[illegible]	.08	1.50	2.00	18.0 -21.0	9.0 -12.0	2.00-3.00	.04	.04	Bal.		2500-2550
	[illegible]	.08	1.50	2.00	18.0 -21.0	9.0 -12.0	2.00-3.00	.04	.04	Bal.		2600[illegible]

Chemical Compositions of Stainless Steels

Wrought Stainless Steels									
Alloy	C	Mn	P	S	Si	Cr	Ni	Mo	Others
201	0.15	6.50	0.060	0.030	1.00	17.00	4.50	-	0.25N
202	0.15	9.00	0.060	0.030	1.00	18.00	5.00	-	0.25N
301	0.15	2.00	0.045	0.030	1.00	17.00	7.00	-	-
302	0.15	2.00	0.045	0.030	1.00	18.00	9.00	-	-
303	0.15	2.00	0.20	0.15	1.00	18.00	9.00	0.60	-
303Se	0.15	2.00	0.20	0.06	1.00	18.00	9.00	0.60	0.15Se
304	0.08	2.00	0.045	0.030	1.00	19.00	9.25	-	-
304L	0.03	2.00	0.045	0.030	1.00	19.00	10.0	-	-
309S	0.08	2.00	0.045	0.030	0.75	23.00	13.5	-	-
310S	0.08	2.00	0.045	0.030	1.50	25.00	20.5	-	-
316	0.08	2.00	0.045	0.030	1.00	17.00	12.0	2.5	-
316L	0.03	2.00	0.045	0.030	1.00	17.00	12.0	2.5	-
317	0.08	2.00	0.045	0.030	1.00	19.00	13.0	3.5	-
317L	0.03	2.00	0.045	0.030	1.00	19.00	13.0	3.5	-
321	0.08	2.00	0.045	0.030	1.00	18.00	10.5	-	Ti 5 X C
329	0.10	2.00	0.045	0.030	1.00	27.50	4.5	1.50	-
330	0.08	2.00	0.040	0.030	1.00	18.50	35.5	-	-
347	0.08	2.00	0.045	0.030	1.00	18.00	11.0	-	Cb+Ta 10 X C
409	0.08	1.00	0.045	0.045	1.00	11.50	35.5	-	Ti 6 x C
410	0.15	1.00	0.040	0.030	1.00	12.50	-	-	-
416	0.15	1.25	0.040	-	1.00	13.00	-	0.60	S =0.15 min.
416Se	0.15	1.25	0.060	0.060	1.00	13.00	-	-	0.15 Se
420	0.15 min.	1.00	0.040	0.030	1.00	13.00	-	-	-
430	0.12	1.00	0.040	0.030	1.00	17.00	-	-	-
440C	1.00	1.00	0.040	0.030	1.00	17.00	-	-	-
442	0.20	1.00	0.040	0.030	1.00	20.50	-	-	-
904L	0.02	2.00	0.045	0.035	1.00	21.00	25.5	4.5	Cu 1.5
17-4 PH	0.07	1.00	0.045	0.035	1.00	16.5	5.5	-	Cu 3-5, 0.4 Al
17-7 PH	0.09	1.00	0.045	0.035	1.00	17.0	7.0	-	.75-1.5 Al
2205	0.03	2.00	0.030	0.020	1.00	22.0	5.5	3.0	0.15 N
Cast Stainless Steels									
CA-6NM	0.06	1.00	0.045	0.035	1.00	12.50	4.00	0.70	-
CA-15	0.15	1.00	-	-	1.50	12.50	1.00	-	-
CA-40	0.40	1.00	-	-	1.50	12.50	1.00	-	-
CF-3	0.03	1.50	0.040	0.040	2.00	19.00	10.00	-	-
CF-3M	0.03	1.50	0.040	0.040	1.50	19.00	10.00	2.5	-
CF-8	0.08	1.50	0.040	0.040	2.00	19.00	9.00	-	-
CF-8M	0.08	1.50	0.040	0.040	2.00	19.50	10.00	2.5	-
CH-20	0.20	1.50	0.040	0.040	1.50	20.00	10.00	-	-
CK-20	0.20	2.00	0.040	0.040	2.00	25.00	20.00	-	-
HF	0.30	2.00	0.040	0.040	2.00	19.00	9.00	-	-

HH	0.35	2.00	0.040	0.040	2.00	25.00	12.00	-	0.2 N
HK	0.30	2.00	0.040	0.040	2.00	25.00	20.00	-	-

Kubota Grade:
A.S.T.M. Specifications: A 743, A 744, A 890
AISI:

Composition - (%) (i)

C	Mn	Si	P	S	Cr	Ni	Mo	Other
0.04	1.00	1.00	0.04	0.04	24.5-26.5	4.75-6.0	1.75-2.25	Cu 2.75-3.25

I think this is the one they call CD4MCu

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ELECTRALLOY

MATERIAL SAFETY DATA SHEET

SECTION I

MSDS#: AH0906B

DATE: May 20, 1999

MANUFACTURER'S NAME:	Electralloy
EMERGENCY PHONE/FAX:	Phone: (814) 678-4200 FAX: (814) 676-5876
ADDRESS:	175 Main Street, Oil City, PA 16301
PRODUCT NAME:	Low Alloy and Tool Steel
CHEMICAL FAMILY:	Steel
OTHER DESIGNATIONS:	Ingots, Bar, Billet, Plate, Strip, Block, Electrode & Remelt Pig

SECTION II

CHEMICAL COMPONENTS	CAS #	RANGE%	TLV	OSHA PEL
**Nickel	7440-02-0	0-5	1 mg/m^3	1 mg/m^3
Iron (Iron oxide)	1309-37-1	60-99.5	(*2) 5 mg/m^3	10 mg/m^3
Copper	7440-50-8	0-1	1 mg/m^3	1 mg/m^3
**Chromium	7440-47-3	0-20	.50 mg/m^3	1 mg/m^3
**Molybdenum	7439-98-7	0-15	10 mg/m^3	15 mg/m^3
Tungsten	7440-33-7	0-21	5 mg/m^3	None
**Cobalt	7440-48-4	0-13	.10 mg/m^3	.10 mg/m^3
Silicon	7440-21-3	0-5	5 mg/m^3	None
Sulfur	7446-09-5	0-0.5	5 mg/m^3	None
**Manganese	7439-96-5	0-5	5 mg/m^3	5 mg/m^3
Titanium	13463-67-7	0-1	5 mg/m^3	15 mg/m^3
**Aluminum	7429-90-5	0-5	(*1-*2) 10 mg/m^3	None
Carbon	1333-86-4	0-4	3.5 mg/m^3	3.5 mg/m^3
**Vanadium	1314-62-1	0-15	(*1) .05mg/m^3	.50 mg/m^3
			(*2) .05mg/m^3	.10 mg/m^3
Phosphorus	7723-14-0	0-0.5	.1 mg/m^3	.1 mg/m^3
*PNOC		0-25	10 mg/m^3	15 mg/m^3
PNOC Respirable		0-25	3 mg/m^3	5 mg/m^3

N/A = NOT APPLICABLE
UN = UNKNOWN
* PNOC = Particles not otherwise classified.
**SARA Title III, Section 313 Reportable.

(*1) - Limits for Dust
(*2) - Limits for Fumes

ELECTRALLOY

MATERIAL SAFETY DATA SHEET

SECTION III
PHYSICAL DATA

MSDS# AH0906B

Boiling Point (degrees F)	N/A	Specific Gravity (H_2O=1)	7.5-8.5
Vapor Pressure (MM HG)	N/A	Percent Volatile by Volume (%)	N/A
Vapor Density (Air = 1)	N/A	Evaporation Rate (H_2O=1)	N/A
Solubility in Water	N/A	Melting Point	2500-2800°F

Appearance & Odor: Metallic and odorless solid.

SECTION IV
FIRE AND EXPLOSION HAZARD DATA

Flash Point (method used)	N/A	Flammable Units	N/A
Extinguishing Media	N/A	( )	LEL
Special Fire Fighting Procedures	N/A	( )	UEL
Unusual fire explosion hazards	N/A		

SECTION V
HEALTH HAZARD DATA

(X) Major Exposure Hazard	(X) Inhalation	( ) Skin Contact
	( ) Ingestion	( ) Skin Absorption

NOTE: Steel products in the natural state do not present an inhalation, injection, or contact hazard. However, operation such as burning, welding, sawing, brazing, or grinding may result in the following effects if exposures exceed permissible limits:

ACUTE: Excessive inhalation of fumes from many metals can produce an acute reaction known as "metal fume fever". Symptoms consist of chills and fever (very similar to the flu type symptoms) which come on in a few hours after high levels of exposure.

CHRONIC: Excessive and repeated overexposure of nickel and chromium can cause various forms of dermatitis, inflammation and/or ulceration of upper respiratory tract. Both chromium and nickel have been associated with upper respiratory cancer. Excessive and repeated overexposure of iron fumes can cause siderosis. Excessive and prolonged inhalation of manganese fumes can cause bronchitis, pneumonitis, lack of coordination.

EMERGENCY FIRST AID PROCEDURES:

In case of excessive exposure, remove to fresh air, administer oxygen, and contact physician immediately.

ELECTRALLOY

MATERIAL SAFETY DATA SHEET

SECTION VI
REACTIVITY DATA

MSDS # AH0906B

(X) Stable ( ) Unstable Conditions to Avoid: N/A
Incompatibility (materials to avoid): N/A
Decomposition Products: N/A
Hazardous ( ) May occur Conditions to Avoid : N/A
Polymerization (X) Will not occur

SECTION VII
SPILL OR LEAK PROCEDURE

Steps to be taken in case material is released or spilled: N/A

Waste disposal method: Dispose in accordance with federal, state, local regulations.

Precautions to be taken in handling and storage: N/A

SECTION VIII
PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:

For welding, burning, grinding, and cutting operations, local ventilation should be provided. If fumes or dust cannot be controlled with exhaust ventilation, an appropriate NIOSH - approved respirator should be used to prevent excessive inhalation exposure.

GLOVES: Gloves may be necessary to prevent skin sensitization and dermatitis.

EYE PROTECTION: Approved safety glasses or goggles should be worn when working with dusty metals.

PREPARED BY: ELECTRALLOY

WHILE THE INFORMATION AND RECOMMENDATIONS SET FORTH ON THIS DOCUMENT ARE BELIEVED TO BE ACCURATE AS OF PRESENT DATE,

THE COMPANY MAKES NO REPRESENTATION OR WARRANTY WITH RESPECT THERETO AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

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Prepared by MST Q.C. Department, South Lyon

Issue Date: 11/15/85
Revised: March 1, 1987
July 1, 1990
Sept. 30, 1993
Jan. 6, 1998
(Expiration per WHMIS
January 2001)

(In accordance with OSHA Standard 1910.1200)

Material Safety Data Sheet

Carbon & Alloy Steel Tubing

I - IDENTIFICATION

:OMMON DESCRIPTION:
Carbon or Alloy - Seamless or Welded
Cold Drawn or Hot Finish - Mechanical
or Pressure - To AISI, ASTM. ASME,
API, MILT and Other Specifications

VISION METALS, INC.
400 McMunn
South Lyon, MI 48178
(248) 437-2742
(800) 521-8416
Emergency Tel. # (248) 486-0143

II- INGREDIENTS

eamless Steel Tubing manufactured from solid steel billet and /or Welded Steel Tubing formed from flat roll steel is available in a road range of Standard published chemistry grades. Formulation of a particular grade is referenced in the Test Report prepared ıd made part of the actual shipment. Steel tube products, per se, under normal conditions do not present an inhalation, inges-on or contact health hazard. The base metal iron (Fe) and alloying ingredients' percentages by weight vary from grade to grade, y exposure limits for specific elements are as follows:

ELEMENTS	CAS NUMBER	% WEIGHT	OSHA PEL (EXPOSURE LIMITS IN MG/M$_3$)	ACGIH TLV
:ON (Fe)	7439-89-6	65.0/99.4	10.0-Iron oxide fume	5.0-Iron oxide fume
ALUMINUM (Al)	7429-90-5	.001/1.30	15.0 Dust 5.0 Respirable	10.0 as Al_2O_3
BISMUTH (Bi)	7440-69-9	.10/.15	None established	None established
CARBON (C)	7440-44-0	.01/1.10	None established	3.5 as carbon black
CHROMIUM (Cr)*	7440-47-3	.01/20.0	1.0 as Cr metal .05-soluble Cr salts	.05 as Cr metal 0.05-Cr compounds
COLUMBIUM (Cb)	7440-03-1	.01/.25	None established	None established
COPPER (Cu)	7440-50-8	.01/.60	0.1-fume/1.0-dust	0.2-fume/1.0-fume dust/mist
LEAD (Pb)*	7439-92-1	.15/.35	.05-Pb dust or fume	.15-Pb dust/1.0-fume
MANGANESE (Mn)*	7439-96-5	.25/2.00	Dust 5.0 Stel 3.0 Fume 1.0 Ceiling 5.0	5.0-dust/1.0-fume
MOLYBDENUM (Mo)	7439-98-7	0.01/1.10	10.0 Dust	10.0-as insoluble or 5.0-soluble compounds
NICKEL (Ni)*	7440-02-0	.01/11.0	1.0 as Ni metal and insoluble compounds	1.0 as Ni metal and insoluble compounds
PHOSPHORUS (P)*	7723-14-0	0.15 Max.	None for inorganic	.01 as Phosphorus (P)
SILICON (Si)	7440-21-3	.15/2.20	0.1 Dust/Fume	10.0 total dust
~ULFUR (S)	7704-34-9	.001/3.5	13.0 as SO_2	5.0 as SO_2
~ANADIUM (V)	7440-62-2	.01/.50	0.05 dust 0.05 fume	.05 as respirable dust and fume

Also, see Section X

NOTE: All commercial metals contain small amounts of elements in addition to those specified. These small quantities, frequently referred to as "trace" or "residual" elements, generally originate in the raw materials used. Typical levels of commonly involved trace or residual elements that may be encountered in steel products are less than 0.1%/weight.

III - PHYSICAL DATA - SOLID STATE

BOILING POINT - N/A
VAPOR PRESSURE - N/A
VAPOR DENSITY - N/A
SPECIFIC GRAVITY - N/A

MELTING POINT Base Metal - 2650 - 2750°F
APPEARANCE AND ODOR - Metallic Grey/ Metallic Odor
EVAPORATION RATE - N/A
SOLUBILITY IN WATER - N/A

IV - FIRE AND EXPLOSION HAZARD DATA

STEEL TUBE PRODUCTS IN THE SOLID STATE PRESENT NO FIRE OR EXPLOSION HAZARD
National Fire Protection Association (NFPA) Code "O" applies.

FLASH POINT - N/A
FLAMMABLE LIMITS - N/A

EXTINGUISHING MEDIA - N/A (LEL/UEL - N/A)
SPECIAL FIRE FIGHTING PROCEDURES - N/A

UNUSUAL FIRE & EXPLOSION HAZARDS - N/A

V - REACTIVITY DATA

STABILITY:

Steel tube products are stable under normal conditions or use, storage and transport.

INCOMPATIBILITY/HAZARDOUS DECOMPOSITION OR BY-PRODUCTS

They will react with acid to liberate Hydrogen (H) gas. At temperatures above the melting point, fumes containing oxides of iron or alloying elements may be emitted. NFPA Code "O" applies.

HAZARDOUS POLYMERIZATION:

Will not occur.

VI - HEALTH HAZARD DATA

NOTE: Steel products under normal conditions do not present an inhalation, ingestion or contact health hazard. However, operations such as burning, welding, sawing, brazing, grinding, and possibly machining, etc. which results in elevating the temperature of the product to or above its melting point or results in generation of airborne particulates, may present health hazards. Under normal conditions, NFPA Code "O" applies.

ROUTE OF ENTRY - EFFECTS OF OVER-EXPOSURE BY INHALATION:

Chronic inhalation of high concentrations of iron oxide fumes or dusts may lead to a benign pneuoconiosis (siderosis). Inhalation of high concentrations of ferric oxide may possibly enhance the risk of lung cancer development in workers exposed to pulmonary carcinogens.

The inhalation of high concentrations of freshly formed oxide fumes and dusts of Manganese (Mn), Copper (Cu), and/or Lead (Pb), in the respirable particle size range can cause an influenza-like illness termed "metal fume fever." Typical symptoms last 12 to 48 hours and are characterized by metallic taste in mouth, dryness and irritation of the throat, followed by weakness, muscle pain, fever and chills.

Inhalation or ingestion of Lead (Pb) particles may result in lead-induced systemic toxicity. Symptoms of lead poisoning include abdominal cramps, anemia, muscle weakness and headache. Prolonged exposures can cause behavioral changes, kidney damage, peripheral neuropathy characterized by decreased hand-grip strength and adverse human reproductive effects.

EMERGENCY AND FIRST AID PROCEDURES:

For over-exposure to airborne fumes and particulates, remove exposed person to fresh air. If breathing is difficult or has stopped, administer artificial respiration or oxygen as indicated. Seek medical attention promptly. Treat metal fume fever by bed rest, and administer a pain and fever reducing medication. Workers who experience the symptoms of lead poisoning should be removed from exposure and receive medical care and guidance. Detailed biological testing and evaluation of possible exposure conditions are required to diagnose and control Lead poisoning. Restriction from exposure to Lead may be required.

VII - SPILL OR LEAK PROCEDURES

NOT APPLICABLE TO STEEL TUBING IN THE SOLID STATE

VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY	NIOSH/MSHA - approved dust and fume respirators should be used to avoid excessive inhalation of particulates. Appropriate respirator selection depends upon the magnitude of exposure.
SKIN	Protective gloves should be worn as required for welding, burning, or handling operations.
EYE	Use safety glasses or goggles as required for welding, burning, sawing, brazing, grinding or machining operations.
VENTILATION	Local exhaust ventilation should be provided when welding, burning, sawing, brazing, grinding or machining to prevent excessive dust or fume exposure.
OTHER	Provide clean coveralls or similar full-body protective clothing on a weekly basis to workers exposed to Lead (Pb) concentrations above levels of 0.05 mg/M^3. Daily changes if exposures exceed 0.2 mg/M^3).
INGESTION	Wash hands before eating or smoking to prevent ingestion of particulates.

IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:
Operations with the potential for generating high concentrations of airborne particulates should be evaluated and controlled as necessary. Avoid breathing metal fumes and/or dusts.

X - OTHER COMMENTS

As part of the cold draw tube manufacturing process, various lubricants and/or drawing compounds are used to reduce friction. Generally, such coating are removed during the drawing or annealing operations and, in some cases, a surface residue may remain. Coatings, oils, and the like, can be applied to protect the finished product surface during shipment and storage. Protective gloves are recommended to minimize minor skin irritation, if any, resulting from contact with such coatings. A list of residual chemicals and suppliers is available upon request. Wash hands after handling oiled material.

IARC (Suppl. 1,29-39,1979) has determined that there is sufficient evidence of increased lung cancer among workers in the chromate-producing industry and possible chromium alloy workers. This determination is supported by sufficient evidence for carcinogenicity to animals and possible mutagenicity testing of Cr VI compounds.
IARC (11,75-112,1976) has determined that there is at least limited evidence that nickel and certain nickel compounds may be human carcinogens. Several nickel (Ni) compounds are carcinogenic to laboratory animals by various routes of exposure. Lead is a known or suspected carcinogen as listed by NTP, IARC or OSHA.

*SARA Section 313 - These chemicals are subject to Section 313 reporting.

** No ozone depleting chemicals are used in our manufacturing.

Steel is a recyclable product, dispose of according to local, state and/or federal regulations.

- CARBON AND/OR ALLOY STEEL TUBING -

WARNING!! - Particulates may be harmful if inhaled or ingested. If steel grade contains Chromium, Nickel or Lead, exposure may create cancer risk. Avoid breathing fumes or dust. Adequate ventilation required in welding, sawing, brazing, grinding or machining operations. FIRST AID: For exposure to airborne dust and fumes, remove exposed person to fresh air. If breathing is difficult or has stopped, administer artificial respiration or oxygen as indicated and seek medical attention promptly.

VISION METALS

The above label can be reproduced or the information contained therein extracted according to the composition of the steel and the varying degrees of hazards associated with the chemical involved.

304 Stainless Steel

316L_SS ANALYSIS OF STAINLESS STEEL 10/14/00 15:58

Quality ASTM A744 CF-8

Average of 2 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						18.00		8.00		
X	0.0184	1.11	0.560	0.0151	.00219	18.70	0.158	8.94	.00323	0.0933
Max	0.0800	2.00	1.50	0.0400	0.0400	21.00		11.00		

	Cu	Nb	Ti	V	W	Fe
Min						
X	0.108	<0.0105	.00213	0.0758	0.0345	70.16
Max						

Remelt Sources, Inc.
27151 Tungsten Road • Cleveland, Ohio 44132-2940

9/25/98

OUR ORDER NO. 980829
YOUR ORDER NO. 9540MS
HEAT 9832966
DESCRIPTION 25-5PH STAINLESS VOD INGOTS, TO ASTM A351/A743/
A744 GRADE CD4MCU1 CHEMISTRY.
SIZE. 15 LB
CONTRACT WEIGHT 4,364.0

C E R T I F I E D   H E A T   A N A L Y S I S

C	0.017
MN	0.45
P	0.019
S	0.014
SI	0.52
NI	5.70
CR	24.87
MO	1.84
CU	2.83
N2	0.113
AL	.002
SN	.001
FE	BAL

The above heat chemistry was provided to us by the original producer or source of the material. Copies of the original source certification are retained on file in our office.

Harry E. Rupert / [illegible]

HARRY E. RUPERT, Q.A. MANAGER

216-289-4555 • FAX: 216-289-0939 • 1-800-CASTMETals • www.remelt.com e-mail remelt@apk.net

Remelt Sources, Inc.
27151 Tungsten Road • Cleveland, Ohio 44132-2940

4/11/00

OUR ORDER NO.	991477
YOUR ORDER NO.	11088MS
HEAT	88728
DESCRIPTION/SPEC	17-4PH Stainless VOD concast bars AMS 5342D/5343D/4344D/5355D; IC 17-4PH; ASTM A747 CB7CU-1
SIZE	2-3/4" Rd x 2'-25'
CONTRACT WEIGHT	3000

C E R T I F I E D   H E A T   A N A L Y S I S

C	.0500
MN	.490
P	.013
S	.001
SI	.850
NI	4.40
CR	16.39
MO	.087
CU	3.07
N2	.0220
CO	.047
W	.011
V	.098
FE	BAL
AL	.004
SN	.006
NB	.183
TA	.009
O2	.0022

The above heat chemistry was provided to us by the original producer or source of the material. Copies of the original source certification are retained on file in our office.

Brandon J. Hunt, Materials Manager

216-289-4555 • FAX: 216-289-0939 • 1-800-CASTMETals • www.remeltsources.com

CERTIFICATION

Customer __________ Order No. 3929

Date 08/27/1998 Alloy 316L

Specification ASTM A351, A743, AND A744 GR CF3M PO# 9510-MS

HEAT NO.: D3042

C	Mn	P	S	Si	Ni	Cr	V	W	Mo
.020	1.32	.020	.038	1.36	10.44	18.75	.06	.03	2.16

Co	Cu	Al	Fe
.09	.15	.03	BAL

We hereby certify that the foregoing is a true copy of the data resulting from tests performed in our laboratory. Since no mechanical tests were run, we cannot certify whether or not this material meets any mechanical property specification for the final product.

GREENVILLE METALS, INC.

Authorized Agent Vice President-Quality Assurance
Title

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FOSECO INC.

MATERIAL SAFETY DATA SHEET
(29 CFR PART 1910.1200 -HAZARD COMMUNICATION)

SECTION 1 - IDENTIFICATION

MATERIAL/PRODUCT: FEEDOL 9
MANUFACTURER/DISTRIBUTOR: Foseco, Inc.
ADDRESS: 20200 Sheldon Road
Brook Park, Ohio 44142

MSDS REV. NO.: 4
DATE PREPARED: November 27, 1990
PREPARER: Trevor Hardy
DURING NORMAL BUSINESS HOURS
TELEPHONE: (216) 826-4548
OUTSIDE NORMAL BUSINESS HOURS
TELEPHONE: CHEMTREC 1-800-424-9300

SECTION 2 - HAZARDOUS COMPONENTS

HAZARDOUS COMPONENT	CAS NO.	%	OSHA PEL (mg/M3)	ACGIH TLV (mg/M3)	OTHER LIMITS
					N/A
*Sodium Nitrate	7631-99-4	<15	15	10	N/A
Sodium Aluminum Fluoride	15096-52-3	<5	2.5 as F	2.5 as F	N/A
**Silica (Quartz)	14808-60-7	<40	0.1 (respirable)	0.1 (respirable)	N/A
[illegible]ium Silicofluoride	16893-85-9	<5	2.5 as F	2.5 as F	N/A
[illegible]uminum	7429-90-5	<30	10	10	N/A

*Physical Hazard - Oxidizer
**Contains no respirable silica in as-supplied form.
[illegible]duct generates high temperature when ignited due to exothermic reaction of [illegible]luminum.

SECTION 3 - PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING PT: N/A
VAPOR PRESSURE: N/A
VAPOR DENSITY: N/A
APPEARANCE AND ODOR: Gray powder. No odor.

APPARENT DENSITY: 1.2
EVAPORATION RATE: N/A
SOLUBILITY IN WATER: Moderate

SECTION 4 - FIRE AND EXPLOSION DATA

FLASH POINT: N/A FLAMMABLE LIMITS: Lel: N/A Uel: N/A
EXTINGUISHING MEDIA: Do not use water. Isolate fire with sand or other inert material.
SPECIAL FIREFIGHTING PROCEDURES: Water may be used to contain the fire, but direct impingement of the stream on the mass of exothermic should be avoided remove burning material from building if possible.
UNUSUAL FIRE & EXPLOSION HAZARDS: Avoid atmospheric dust clouds when handling, mixing, etc. especially in presence of sparks, open flames, heated appliances etc.

[illegible]ION 5 - REACTIVITY DATA

STABILITY: Stable
INCOMPATIBILITY: Open flames, caustic, acid or acid fumes.
HAZARDOUS POLYMERIZATION: Will not occur.
HAZARDOUS DECOMPOSITION PRODUCTS: Fluorides oxides of nitrogen and carbon.

Page -2- MATERIAL/PRODUCT: FEEDOL 9

SECTION 6 - HEALTH HAZARD DATA

ROUTE(S) OF ENTRY: INHALATION (YES) SKIN (NO) EYES (NO) INGESTION (NO)
HEALTH HAZARDS: ACUTE Fluorides can cause skin and eye burns and irritation of mucous membranes. Excessive inhalation may cause nose bleeds.
HEALTH HAZARDS: CHRONIC Fluorides can cause loss of appetite, vomiting, increas in bone density. NIOSH lists eyes, respiratory system, CNS, skeleton, kidneys as target organs for fluorides, Inhalation of crystalline silica can cause silicosi
TOXICITY DATA: LD50: Sodium aluminum fluoride 200 mg/Kg orl-rat, Sodium silico fluoride 125 mg/Kg orl-rat.
CARCINOGENICITY: NTP/IARC/OSHA/OTHER: IARC lists crystalline silica as a possible human carcinogen based on tests with laboratory animals.
SIGNS AND SYMPTOMS OF EXPOSURE: Eye, skin, respiratory irritation.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing skin and respiratory ailments.
EMERGENCY AND FIRST AID PROCEDURES:
INHALATION: Remove person to fresh air; call physician.
SKIN: Wash with large amounts of water.
EYES: Flush with water for at least 15 minutes; persistent pain refer to ophthalmologist.
INGESTION: Drink milk. DO NOT INDUCE VOMITING. Refer to physician immediately.

SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE

SPILLS/LEAKS: Remove all sources of open flames. Sweep into container using non sparking tools. Do not use vacuum cleaner or other equipment which may spark
WASTE DISPOSAL: Product contains fluorides. Dispose of residue in accordance with local and other applicable regulations.
HANDLING, USE AND STORAGE: Precautions should be taken to store product below 90°F. When ignited generates high temperatures. Contact with caustic, acid or acid fume will generate toxic and/or flammable fume.

SECTION 8 - CONTROL MEASURES

RESPIRATORY PROTECTION: If PEL/TLV is exceeded use NIOSH approved for inorganic dust.
VENTILATION: Recommended sufficient to maintain below PEL/TLV.
GLOVES: Insulating EYE PROTECTION: Tinted Safety Glasses
OTHER: None

NA = Not Applicable
NK = Not Known

SIGNATURE OF PREPARER: [signature]

Please ensure that all persons coming into contact with this product are aware of the information contained in this MSDS Sheet. Information presented herein has been compiled from sources considered to be reliable and is accurate and reliable to the best of our knowledge and belief but is not guaranteed to be so. It is the user's responsibility to determine for himself the suitability of any material for a specific use and to adopt such safety precautions as may be necessary. If you need any further information from us to make the determinations which you must make to use this material safely, please contact the above named preparer.

FOSECO INC.

SUPPLIER NOTIFICATION

FEEDOL* 9

The above listed product contains a toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. The chemical(s) is/are listed below.

CHEMICAL NAME	CAS #	STANDARD WEIGHT %
Aluminum	7429-90-5	27

This notification is attached to the product Material Safety Data Sheet (MSDS) and must not be detached from the MSDS. Any copying or redistribution of the MSDS shall include copying and redistribution of this notice attached to copies of the MSDS subsequently redistributed.

The weight percentages given represent the upper bound concentration level for that listed chemical based upon our knowledge of the raw materials comprising this product.

Signature of Preparer: T Hardy

*Registered Trademark

FOSECO INC.

MATERIAL SAFETY DATA SHEET
(29 CFR PART 1910.1200 -HAZARD COMMUNICATION)

SECTION 1 - IDENTIFICATION

MATERIAL/PRODUCT: FERRUX 107F
MANUFACTURER/DISTRIBUTOR: Foseco, Inc.
ADDRESS: 20200 Sheldon Road
Brook Park, Ohio 44142

MSDS REV. NO.: 3
DATE PREPARED: November 16, 1990
PREPARER: Trevor Hardy
DURING NORMAL BUSINESS HOURS
TELEPHONE: (216) 826-4548
OUTSIDE NORMAL BUSINESS HOURS
TELEPHONE: CHEMTREC 1-800-424-9300

SECTION 2 - HAZARDOUS COMPONENTS

HAZARDOUS COMPONENT	CAS NO.	%	OSHA PEL (mg/M3)	ACGIH TLV (mg/M3)	OTHER LIMITS
*Sodium Nitrate	7631-99-4	<10	15 (total)	N/A	No
Sodium Silicofluoride	16893-85-9	<10	2.5 as F	2.5 as F	No
Aluminum (metal and Oxides)	7429-90-5	>50	10	10	No
Iron Oxide	1309-37-1	<10	10 (as fume)	5 (as fume)	No
Perlite	55465-40-2	<20	15 (total)	10	No

*Oxidizer. This product generates high temperatures when ignited due to exothermic reaction of aluminum.

SECTION 3 - PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING PT: N/A
VAPOR PRESSURE: N/A
VAPOR DENSITY: N/A
BULK DENSITY: 0.8 g/cc
EVAPORATION RATE: N/A
SOLUBILITY IN WATER: Moderate
APPEARANCE AND ODOR: Reddish brown powder. No odor.

SECTION 4 - FIRE AND EXPLOSION DATA

FLASH POINT: None
FLAMMABLE LIMITS: Lel: N/A Uel: N/A
EXTINGUISHING MEDIA: Do not use water. Isolate fire with sand or other inert material.
SPECIAL FIREFIGHTING PROCEDURES: Water may be used to contain the fire, but direct impingement of the stream on the mass of exothermic should be avoided.
UNUSUAL FIRE & EXPLOSION HAZARDS: Avoid atmospheric dust clouds when handling especially in presence of open flames, sparks, heating apparatus.

SECTION 5 - REACTIVITY DATA

STABILITY: Stable
INCOMPATIBILITY: Open flames, caustic, acid or acid fume.
HAZARDOUS POLYMERIZATION: Will not occur.
HAZARDOUS DECOMPOSITION PRODUCTS: Oxides of nitrogen, fluorides, some chlorides.

N/A = Not Applicable
N/K = Not Known

SECTION 6 - HEALTH HAZARD DATA

ROUTE(S) OF ENTRY: INHALATION (YES) SKIN (YES) EYES (YES) INGESTION (NO)
HEALTH HAZARDS: ACUTE Fluorides can cause skin and eye burns and irritation mucous membranes. Excessive inhalation may cause nose bleeds.
HEALTH HAZARDS: CHRONIC Fluorides can cause loss of appetite, vomiting, increase in bone density. NIOSH lists eyes, respiratory system, CNS, skeleton, kidneys, skin as target organs for fluorides.
TOXICITY DATA: LD50 orl-rat for sodium silicofluoride is 125mg/Kg.
CARCINOGENICITY: NTP/IARC/OSHA/OTHER: N/A

SIGNS AND SYMPTOMS OF EXPOSURE: Eye, skin, respiratory irritation.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing skin and respiratory ailments.
EMERGENCY AND FIRST AID PROCEDURES:
INHALATION: Remove person to fresh air.
SKIN: Wash with cold water.
EYES: Immediately flush with water for at least 15 minutes.
INGESTION: N/A

SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE

SPILLS/LEAKS: Remove all sources of open flames. Sweep into container using no sparking tools. Minimize dust levels.
WASTE DISPOSAL: Dispose of in accordance with local, state and federal regulations.
HANDLING, USE AND STORAGE: Store below 150°F in dry area. Keep containers closed when not in use. Avoid contact with acids or caustics which will react to produce flammable hydrogen gas.

SECTION 8 - CONTROL MEASURES

RESPIRATORY PROTECTION: If PEL/TLV is exceeded use NIOSH approved dust mask.
VENTILATION: Recommended sufficient to maintain below PEL/TLV.
GLOVES: Insulating EYE PROTECTION: Tinted safety glasses with side shields
OTHER: N/A

N/A = Not Applicable
N/K = Not Known

SIGNATURE OF PREPARER: T Hardy

Please ensure that all persons coming into contact with this product are aware of the information contained in this MSDS Sheet. Information presented herein has been compiled from sources considered to be reliable and is accurate and reliable to the best of our knowledge and belief but is not guaranteed to be so It is the user's responsibility to determine for himself the suitability of any material for a specific use and to adopt such safety precautions as may be necessary. If you need any further information from us to make the determinations which you must make to use this material safely, please contact the above named preparer.

FOSECO INC.

SUPPLIER NOTIFICATION

FERRUX* 107F

The above listed product contains a toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. The chemical(s) is/are listed below.

CHEMICAL NAME	CAS #	STANDARD WEIGHT %
Aluminum	7429-90-5	25.0

This notification is attached to the product Material Safety Data Sheet (MSDS) and must not be detached from the MSDS. Any copying or redistribution of the MSDS shall include copying and redistribution of this notice attached to copies of the MSDS subsequently redistributed.

The weight percentages given represent the upper bound concentration level for that listed chemical based upon our knowledge of the raw materials comprising this product.

Signature of Preparer: THardy

* Registered Trademark

MSDS NO.	4932
PRODUCT CODE NO.	1747
'' NO.	None

Material Safety Data

Union Oil Company of California

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CARBON GROUP

MANUFACTURER	
UNION CHEMICALS DIVISION, UNION OIL COMPANY OF CALIFORNIA 461 SOUTH BOYLSTON STREET LOS ANGELES, CALIFORNIA 90017 (213) 977-7600	Transportation Emergencies: Call CHEMTREC (800) 424-9300 For AK & HI: (202) 483-7616 Health Emergencies: Call Los Angeles Poison Information Center (24 hrs.) (213) 664-2121

PRODUCT	CALCINED PETROLEUM COKE, CALCINED NEEDLE PETROLEUM COKE
COMMON NAME	COKE
GENERIC NAME	CARBON RAISER
CHEMICAL NAME	CARBON
CHEMICAL FAMILY	CARBON
DOT PROPER SHIPPING NAME	PETROLEUM COKE

WARNING STATEMENTS

WARNING
Avoid breathing dust.
Use with adequate ventilation.
FOR INDUSTRIAL USE ONLY

SECTION I - INGREDIENTS

*THRESHOLD LIMIT VALUE SET BY: A. OSHA B. ACGIH C. SEE SECTION III D. OTHER NE. NOT ESTABLISHED
UNITS ARE IN ppm UNLESS SPECIFIED OTHERWISE.

	%	TLV*
Respirable Dust		5 mg/m^3 A,B
Total Dust		10 mg/m^3 B 15 mg/m^3 A

PRODUCT: CALCINED PETROLEUM COKE, CALCINED NEEDLE PETROLEUM COKE

SECTION II - EMERGENCY AND FIRST AID PROCEDURES

EMERGENCY: HAVE PHYSICIAN CALL LOS ANGELES POISON INFORMATION CENTER (24 hrs.) (213) 664-2121

EYE CONTACT	Holding the lids apart, flush contaminated eye(s) with a gentle stream of water for 15 minutes. If irritation or redness develops and persists, seek immediate medical attention.
SKIN CONTACT	Remove contaminated clothing and cleanse skin thoroughly with soap and water. Seek medical attention if skin irritation or redness persists.
INHALATION	No first aid is normally required. However, seek fresh air and medical attention if breathing difficulties develop.
INGESTION	Drink two or three cups of milk or water. No other first aid is normally required. However, if any unusual symptoms develop, seek medical advice.

SECTION III - PHYSIOLOGICAL EFFECTS AND HEALTH INFORMATION

EYE EFFECTS	This product may be an eye irritant.
SKIN EFFECTS	Prolonged or repeated skin contact may result in skin irritation.
ACUTE EFFECTS	Inhalation of dusts may cause respiratory tract irritation.
CHRONIC EFFECTS	Repeated exposure can lead to accumulation of dust in the lung, resulting in inflammation and, in time, pulmonary fibrosis.

SECTION IV - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFY TYPE)	If exposure exceeds the applicable TLV, a suitable filter-type respirator should be worn. (SEE ADDENDUM)
VENTILATION	General mechanical ventilation may be adequate for maintaining airborne concentrations below established exposure limits. If general ventilation is inadequate, supplemental local exhaust may be required. Other special precautions, such as respiratory protection, may be required if airborne concentrations cannot be reduced to below the recommended exposure limit by ventilation.
PROTECTIVE GLOVES	The use of protective gloves is recommended.
EYE PROTECTION	Appropriate protection from dust is recommended.
OTHER PROTECTIVE EQUIPMENT	None

SECTION V - REACTIVITY DATA

STABILITY	STABLE
CONDITIONS TO AVOID	
INCOMPATIBILITY (MATERIALS TO AVOID)	Avoid contact with strong oxidizing agents such as peroxides and nitric acid.
HAZARDOUS DECOMPOSITION PRODUCTS	Thermal decomposition in the presence of air may yield carbon monoxide and/or carbon dioxide. At extremely high temperatures this product may react with water to form carbon dioxide, carbon monoxide and hydrogen gas.
HAZARDOUS POLYMERIZATION	WILL NOT OCCUR
CONDITIONS TO AVOID	

SECTION VI - SPILL OR LEAK PROCEDURES

HIGHWAY OR RAILWAY SPILLS, CALL CHEMTREC (800) 424-9300

PRECAUTIONS IN CASE OF RELEASE OR SPILL	Wet down to prevent blowing material.
WASTE DISPOSAL METHOD	Dispose of product in accordance with applicable local, county, state and federal regulations.

SECTION VII - STORAGE AND SPECIAL PRECAUTIONS

HANDLING STORING PRECAUTIONS	Minimize dust generation.
OTHER PRECAUTIONS	None

SECTION VIII - FIRE AND EXPLOSION HAZARD DATA

DOT FLAMMABILITY CLASSIFICATION	Not Classified	FLASH POINT RANGE	Not Applicable
EXTINGUISHING MEDIA	Break up pile to help cool and drench with water.		
UNUSUAL FIRE AND EXPLOSION HAZARDS	Water may react with coke to form carbon dioxide, carbon monoxide and hydrogen gas at extemely high temperatures.		
FIRE FIGHTING PROCEDURES			

SECTION IX - PHYSICAL DATA

APPROXIMATE BOILING RANGE	VAPOR DENSITY	EVAPORATION RATE	PERCENT VOLATILE	SOLUBILITY IN WATER
Not Applicable	Not Applicable	Not Applicable	None	None

SPECIFIC GRAVITY	APPROXIMATE BULK DENSITY
Heavier than water (2.10 g/cc - typical)	0.75 g/cc

APPEARANCE AND ODOR	Steel gray to black particles. No odor.

SECTION X - DOCUMENTARY INFORMATION

PRODUCT CODE NO.	ISSUE DATE	REPLACES MSDS NO.	PREVIOUS PRODUCT CODE NO.	PREVIOUSLY ISSUED
1747	1/16/84	4722	1747	8/83

DISCLAIMER OF EXPRESS AND IMPLIED WARRANTIES

The information in this document is believed to be correct as of the date issued. HOWEVER, NO WARRANTY OF MERCHANTABILITY, FITNESS FOR ANY USE, OR ANY OTHER WARRANTY IS EXPRESSED OR IS TO BE IMPLIED REGARDING THE ACCURACY OR COMPLETENESS OF THIS INFORMATION, THE RESULTS TO BE OBTAINED FROM USE OF THIS INFORMATION OR THE PRODUCT, THE SAFETY OF THIS PRODUCT, OR THE HAZARDS RELATED TO ITS USE. This information and the product are furnished on the condition that the person receiving them shall make his own determination as to the suitability of the product for his particular purpose and on the condition that he assume the risk of his use thereof.

ADDENDUM

Section IV - SPECIAL PROTECTION INFORMATION

Respiratory Protection:

In case of concurrent vapor or gas exposure, depending on the airborne concentration, an appropriate filter and cartridge respirator, gas mask and canister (NIOSH approved, if available), or supplied-air equipment should be worn.

Occupational Safety and Health Administration

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SLAG GEL FLUX #442

SECTION I

MANUFACTURER'S NAME GREFCO, Inc., Minerals Division	EMERGENCY TELEPHONE NO. (213) 325-5411 or 381-5081
ADDRESS (Number, Street, City, State, and ZIP Code) 3450 Wilshire Boulevard, Los Angeles, CA 90010	
CHEMICAL NAME AND SYNONYMS Perlite, volcanic glass	TRADE NAME AND SYNONYMS Slag Gel Flux
CHEMICAL FAMILY Amorphous siliceous mineral-Silicate	FORMULA A sodium potassium aluminum silicate of variable composition.

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS		%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS	–			BASE METAL		
CATALYST	–			ALLOYS		
VEHICLE	–			METALLIC COATINGS		
SOLVENTS	–			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES	–			OTHERS		
OTHERS	–					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
Perlite Ore		
(Quartz less than 1.0%; Cristobalite less than 1.0%-nuisance dust)	100	

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)	–	SPECIFIC GRAVITY (H_2O=1)	2.35
VAPOR PRESSURE (mm Hg.)	–	PERCENT, VOLATILE BY VOLUME (%)	–
VAPOR DENSITY (AIR=1)	–	EVAPORATION RATE (______ =1)	–
SOLUBILITY IN WATER	slight		
APPEARANCE AND ODOR	Dry gray to grayish black or brown. Aggregate or powder. No odor.		

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) Non-flammable	FLAMMABLE LIMITS	Lel	Uel
EXTINGUISHING MEDIA –			
SPECIAL FIRE FIGHTING PROCEDURES –			
UNUSUAL FIRE AND EXPLOSION HAZARDS No hazard			

(Continued on reverse side)

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Rev. May 72

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE $5 Mg/M^3$ respirable dust fraction. See attachment.

EFFECTS OF OVEREXPOSURE Inhalation over long periods of high amounts of any nuisance dust may overload lung clearance mechanism and make lungs more vulnerable to respiratory disease.

EMERGENCY AND FIRST AID PROCEDURES Remove to dust free area. ~~Avoid excessive dust inhalation.~~

SECTION VI - REACTIVITY DATA

STABILITY			CONDITIONS TO AVOID
	UNSTABLE		
Inert	STABLE	X	

INCOMPATABILITY *(Materials to avoid)* Not applicable

HAZARDOUS DECOMPOSITION PRODUCTS Not applicable

HAZARDOUS POLYMERIZATION			CONDITIONS TO AVOID
	MAY OCCUR		
	WILL NOT OCCUR	X	

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED No special precautions. Vacuum clean or sprinkle with floor sweeping compound before sweeping. Maintain good housekeeping procedures regarding nuisance dust.

WASTE DISPOSAL METHOD No special methods. Maintain good housekeeping procedures regarding nuisance dust.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)* Even though perlite is a nuisance dust, we recommend the use of NIOSH approved respirators for protection against pneumoconiosis producing dust.

VENTILATION		
LOCAL EXHAUST	Advisable on prolonged contact	SPECIAL None
MECHANICAL *(General)*	-	OTHER -

PROTECTIVE GLOVES Normally not necessary

EYE PROTECTION If dusting is excessive, use NIOSH approved dust goggles.

OTHER PROTECTIVE EQUIPMENT None

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING Handle to avoid creating dust.

OTHER PRECAUTIONS Federal and State regulations sometimes change and differ. To stay current, consult with your State OSHA Authorities.

GPO 934-110

 While the information and recommendations set forth herein are believed to be accurate as of the date hereof, GREFCO, INC. MAKES NO WARRANTY WITH RESPECT, THERETO, AND DISCLAIMS ALL LIABILITY FROM RELIANCE THEREON.

Form OSHA-20
Rev. May 72

47713

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Material Safety Data Sheet

Effective date: 11/1/94
Preparer: John Brander
Preparer Signature:

I. PRODUCT IDENTIFICATION

Manufacturer: Industrial Gypsum Company, Inc.
PO Box 07091
Milwaukee, WI 53207

Regular Telephone: (414) 747-1889
(800) 877-8917

Emergency Telephone:

Trade name: MASTERTOP 3400

Synonyms: None

Chemical Formula: N/A

Chemical Family: N/A

C.A.S. No.: Mixture

MSDS#35021

II. INGREDIENTS

INGREDIENT EXPOSURE LIMITS — TLV DATA

Material/Component	C.A.S. No.	WT. %	PEL (OSHA)	TWA (ACGIH)	STEL (ACGIH)	Ceiling (OSHA)	IDLH (OSHA)
Al_2O_3	1302-93-8	40-70%	15 mg/m3 10 mg/m3	Total Dust Respirable Dust			
SiO_2	14808-60-7	0-20%	2.5 mg/m3 0.1 mg/m3	Total Dust Respirable Dust			
Aluminum	7429-90-5	0-20%	10 mg/m3	Total Dust	Not Available		
KNO_3	7757-79-1	5-20%	Not Available				
Cryolite (Na_3AlF_6)	15096-52-3	5-20%	2.5mg/m^3 (as F)				

III. PHYSICAL DATA

Appearance and Odor: Gray powder.

Boiling Point: N/A

Density or Specific Gravity: 3.0-4.0

Volatiles: 30-50% by volume
Butyl Acetate = 1
Evaporation Rate: N/A

Vapor Density:
Air = 1

Vapor Pressure: N/A

Freezing Point/
Melting Point: N/A

Solubility in Water: Slight

IV. FIRE, EXPLOSION AND REACTIVITY DATA

Flash Point: 2-3 oz./100 ft. air. Cover to eliminate oxygen.

Flammable Limits in Air: Upper: N/A
Lower: N/A

Extinguishing Media: Avoid water and halogenated extinguishing agents. Air/dust mixture may explode.

Special Fire Fighting Procedure: Use self-contained breathing apparatus in pressure demand mode. Use sand to cover and eliminate oxygen.

Unusual Fire & Explosion Hazard: May emit toxic fluoride fumes if heated to decomposition. Material contains oxidizer which will increase the intensity of fire. Reacts with water, acids, and alkalines.

Stability: Stable under normal conditions.

Conditions Contributing to Instability:

Incompatibility: Avoid water, acids, alkalines, halogenated hydrocarbons and oxidizers.

Conditions Contributing to Hazardous Polymerization: Avoid water and dust. In high temperature, quartz can change crystal structure to form cristobalite (1470°C plus)-and has greater health hazards than quartz.

V. PRODUCT HEALTH HAZARD INFORMATION

Routes of Exposure:

Eye Contact: √

Inhalation: √

Skin Contact: √

Ingestions:

Effects of Overexposure:

Acute Effects: Acute overexposure may cause eye, skin and pulmonary irritation. Chronic overexposure may cause increased bone density. Health hazards can occur from excessive inhalation due to silica dust. Crystalline silica in lung can produce pneumoconiosis.

First Aid Procedures:

Eyes: Flush with copious amounts of water for 15 minutes. Contact a physician immediately.

Inhalation: Remove to fresh air.

Skin: Wash with soap and water.

Ingestion: Large ingested quantities can cause nitrate poisoning.

ther Toxological Properties:

Carcinogenicity: This product contains low levels of crystalline silica which IARC classifies as probably carcinogenic to humans. However, there is no evidence to indicate that the trace amounts of crystalline silica present in this product have a carcinogenic effect. This product is considered a nuisance dust by the ACGIH and OSHA.

VI. DISPOSAL, SPILL OR LEAK PROCEDURES

Procedure for Release or Spill: Remove by sweeping or vacuum.

Waste Disposal Method: Disposal in accordance with all federal, state, and local regulations. Aluminum dust is listed under Section 313 of SARA Title III and is subject to annual emission reporting requirements.

VII. PERSONAL PROTECTION INFORMATION

Ventilation Requirements: When TLV is exceeded use local exhaust.

Specific Personal Protection Equipment:

Respiratory: 3M 8710 mask or cuivalent.

Eyes: Safety glasses or goggles.

Gloves: As needed. Protective gloves should not be conductive.

Others: Long Sleeves.

VII. HANDLING AND STORAGE

Store in a clean, dry area. Avoid smoking. Do not store in automatic sprinklered area.

OCTOBER 12TH, 2000

from this day

SPECTROMETER
QA RESULTS
FOR HEATS 10/12

printed out one or two days later is typical

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT.
Quality 12F CLC
Sample ID 35375 Sample No 6365406 10/14/00 08:46
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.210	0.496	1.10	.00718	.00762	1.00	0.252	1.25	0.0325	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0154	<0.0100	<.00100	<0.0100	<0.0100	95.59	0.730	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT.
Quality 12F CLC
Sample ID 35376 Sample No 6365411/16 10/14/00 08:47
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.225	0.534	1.11	.00727	.00827	0.988	0.239	1.28	0.0239	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0152	<0.0100	.00111	<0.0100	<0.0100	95.53	0.744	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT.
Quality 12F CLC
Sample ID 35377 Sample No 6365406 10/14/00 08:48
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.237	0.455	1.06	0.0115	0.0101	1.00	0.247	1.27	0.0341	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0201	<0.0100	.00102	<0.0100	<0.0100	95.62	0.751	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/14/00 08:49
Quality 12F CLC Sample No 6365411/16
Sample ID 35378
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.219	0.501	1.12	.00773	.00739	0.971	0.239	1.28	0.0218	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0173	<0.0100	<.00100	<0.0100	<0.0100	95.58	0.736	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/14/00 08:49
Quality 12F CLC Sample No 6365403/06/11/16
Sample ID 35379
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.233	0.497	1.08	0.0125	.00836	0.962	0.245	1.29	0.0422	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0189	<0.0100	<.00100	<0.0100	<0.0100	95.57	0.744	0
Max	0.500	0.0200						

CN7M__SS ANALYSIS OF STAINLESS STEEL--CN7M 10/14/00 08:51
Quality ASTM A351 CD4MCu Sample No 6559706
Sample ID 35380
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						24.50	1.75	4.75		
X	0.0289	0.919	0.514	0.0206	.00602	24.71	1.88	5.52	0.0444	0.124
Max	0.0400	1.00	1.00	0.0400	0.0400	26.50	2.25	6.00		

	Cu	Nb	Ti	V	W	Fe	Fc
Min	2.75						
X	2.85	0.0145	.00333	0.0438	0.0448	63.29	2.33
Max	3.25						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/14/00 08:52
Quality ICI 1040 Sample No 6565401
Sample ID 35381
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.350	0.200	0.700							
X	0.416	0.790	0.900	.00726	.00740	0.322	0.0161	0.102	0.0780	<0.0100
Max	0.450	1.00	1.00	0.0400	0.0450	0.350		0.500		

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0360	<0.0100	<.00100	<0.0100	<0.0100	97.29	0.645	0
Max	0.500				0.100			

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/14/00 08:53
Quality IOI 8620 Sample No 6565701
Sample ID 35382
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.150	0.200	0.650			0.400	0.150	0.400		
X	0.229	0.613	0.854	.00966	.00642	0.536	0.212	0.519	0.0688	<0.0100
Max	0.250	0.800	0.950	0.0400	0.0450	0.700	0.250	0.700		

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0331	<0.0100	.00103	<0.0100	<0.0100	96.88	0.559	0
Max	0.600							

FE-STAIN ANALYSIS OF STAINLESS STEEL 10/14/00 08:56
Quality AMS 5344 17-4 Sample No 6473702/6577402
Sample ID 35383
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min		0.500				15.50		3.60		
X	0.0413	0.915	0.508	.00879	<.00100	15.60	0.0839	4.30	0.0403	0.0369
Max	0.0600	1.00	0.700	0.0250	0.0250	16.70		4.60	0.0500	

	Cu	Nb	Ti	V	W	Fe
Min	2.80	0.150				
X	3.27	0.206	.00272	0.0685	0.0141	74.91
Max	3.50	0.400				

ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/17/00 10:36
Quality 12F CLC Sample No 6373805/6365408
Sample ID 35391
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.218	0.517	1.10	0.0104	.00875	1.02	0.244	1.28	0.0458	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0119	<0.0100	.00108	<0.0100	<0.0100	95.51	0.741	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/17/00 10:37
Quality 12F CLC Sample No 6365406/6365408
Sample ID 35392
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.215	0.517	1.13	0.0110	.00775	0.993	0.238	1.28	0.0433	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0147	<0.0100	<.00100	<0.0100	<0.0100	95.51	0.738	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/17/00 10:38
Quality 12F CLC Sample No 6365410/15
Sample ID 35393
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.229	0.496	1.09	0.0107	.00821	0.965	0.244	1.28	0.0278	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0153	<0.0100	<.00100	<0.0100	<0.0100	95.60	0.740	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/17/00 10:39
Quality 12F CLC Sample No 6365410/11/13/15/16
Sample ID 35394
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.233	0.490	1.12	0.0107	.00698	0.978	0.257	1.28	0.0348	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0108	<0.0100	<.00100	<0.0100	<0.0100	95.54	0.754	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/17/00 10:40
Quality 12F CLC Sample No. 6365408/13
Sample ID 35395
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.232	0.515	1.12	.00990	.00734	0.996	0.257	1.28	0.0396	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0186	<0.0100	.00115	<0.0100	<0.0100	95.49	0.757	0
Max	0.500	0.0200						

FE-LAS ANALYSIS OF LOW ALLOY STEEL/RECALIBRAT. 10/17/00 10:41
Quality 12F CLC Sample No 6365408/13/07
Sample ID 35396
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min	0.200	0.300	0.900			0.900	0.200	1.20	0.0150	
X	0.218	0.518	1.11	.00735	0.0124	0.979	0.250	1.27	0.0431	<0.0100
Max	0.240	0.600	1.20	0.0250	0.0250	1.10	0.300	1.40	0.0500	

	Cu	Nb	Ti	V	W	Fe	Ce	Ea
Min								
X	0.0118	<0.0100	.00101	<0.0100	<0.0100	95.53	0.737	0
Max	0.500	0.0200						

316L_SS ANALYSIS OF STAINLESS STEEL 10/17/00 10:42
Quality ASTM-A743-CF3M Sample No 6554302
Sample ID 35397
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						17.00	2.00	9.00		
X	0.0260	1.38	0.694	0.0202	.00216	17.72	2.22	9.92	0.0522	0.0672
Max	0.0300	1.50	1.50	0.0400	0.0400	21.00	3.00	13.00		

	Cu	Nb	Ti	V	W	Fe
Min						
X	0.0814	0.0116	.00278	0.0834	0.0364	67.69
Max						

316L_SS ANALYSIS OF STAINLESS STEEL 10/17/00 10:42
Quality ASTM-A743-CF3M Sample No 6554303
Sample ID 35398
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						17.00	2.00	9.00		
X	0.0238	1.39	0.628	0.0201	<.00100	17.73	2.24	9.95	0.0587	0.0630
Max	0.0300	1.50	1.50	0.0400	0.0400	21.00	3.00	13.00		

	Cu	Nb	Ti	V	W	Fe
Min						
X	0.0927	0.0126	.00347	0.0836	0.0290	67.67
Max						

CN7M__SS ANALYSIS OF STAINLESS STEEL--CN7M 10/17/00 10:43
Quality ASTM A351 CD4MCu Sample No 6559704/6559706
Sample ID 35399
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						24.50	1.75	4.75		
X	0.0328	0.922	0.456	0.0220	.00708	25.00	1.86	5.44	0.0472	0.118
Max	0.0400	1.00	1.00	0.0400	0.0400	26.50	2.25	6.00		

	Cu	Nb	Ti	V	W	Fe	Fn
Min	2.75						
X	2.79	0.0150	.00356	0.0431	0.0415	63.20	2.35
Max	3.25						

CN7M__SS ANALYSIS OF STAINLESS STEEL--CN7M 10/17/00 10:44
Quality ASTM A351 CD4MCu Sample No 6559705
Sample ID 35400
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						24.50	1.75	4.75		
X	0.0336	0.903	0.450	0.0224	.00526	25.05	1.87	5.19	0.0551	0.105
Max	0.0400	1.00	1.00	0.0400	0.0400	26.50	2.25	6.00		

	Cu	Nb	Ti	V	W	Fe	Fn
Min	2.75						
X	2.76	0.0135	.00343	0.0440	0.0367	63.45	2.41
Max	3.25						

316L_SS ANALYSIS OF STAINLESS STEEL 10/17/00 10:48
Quality ASTM A744 CF-8 Sample No 6567701/6534101
Sample ID 35401
Average of 1 sparks

	C	Si	Mn	P	S	Cr	Mo	Ni	Al	Co
Min						18.00		8.00		
X	0.0183	1.33	0.528	0.0152	.00131	18.51	0.165	8.81	0.0562	0.0920
Max	0.0800	2.00	1.50	0.0400	0.0400	21.00		11.00		

	Cu	Nb	Ti	V	W	Fe
Min						
X	0.107	0.0102	.00215	0.0744	0.0399	70.26
Max						

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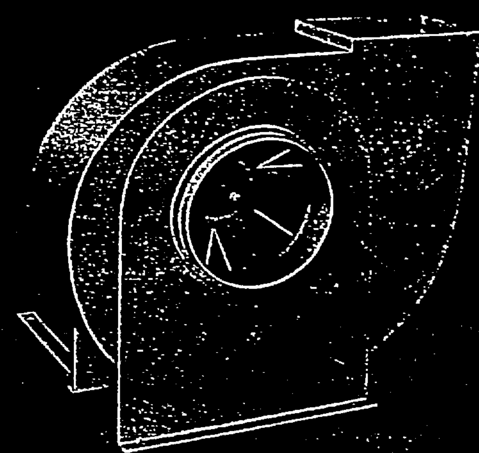
APPENDIX B

(13 pages follow)

American Air Filter Pre-Owned Ventilation Equipment

Bulletin No. 860A

AAF type K industrial exhauster



with exclusive Taper Lock hub

AAF American Air Filter COMPANY, INC.

IGCI

AAF type K exhausters

designed to meet the exacting standards of industrial service

DESIGN ADVANTAGES

1. HIGH EFFICIENCY — maintained over a wide range of operations — A highly desirable feature on local exhaust systems subject to wide variations in static pressures.
2. TAPER LOCK HUB — incorporated on sizes 13 through 42 insures reduced maintenance cost on these heavy duty applications where periodic wheel replacement is anticipated.
3. NEW IMPELLER DESIGN greatly reduces susceptibility to dynamic unbalance. The narrow AAF Type K Impeller reduces the lever length through which unbalance, caused by material accumulations, can act.
4. HEAVY DUTY SHAFT AND BEARINGS insure longer unit life. Narrow wheel design also increases effectiveness of shaft and bearings by reducing length of wheel overhang.
5. COMPLETELY ROTATABLE in 45° increments of discharge positions in the field.
6. COMPLETELY REVERSIBLE in the field to allow either clockwise or counter clockwise rotation. Flexibility offered by items (5) and (6) means the AAF Type K exhauster is never obsolete.

The AAF Type K Exhauster was originally developed to meet the severe requirements — high static pressures, heavy dust concentrations, and, frequently, highly corrosive conditions,— encountered in the application of AAF dust control equipment. Because of its outstanding success in thousands of such installations, the Type K Exhauster has been made available as a separate product.

New thinking in industrial exhauster design is presented by the Type K exhauster. AAF research engineers have always recognized that the more narrow an exhauster wheel could be made, the less it would be affected by unbalance caused by material accumulation. It is also recognized that a narrow wheel design greatly increased the effectiveness of shafts and bearings by reducing the distance from the outer wheel periphery to the fixed point (bearing). Reduction of this distance decreases proportionately the force acting on the shaft and bearings — allowing greater wheel loads to be handled.

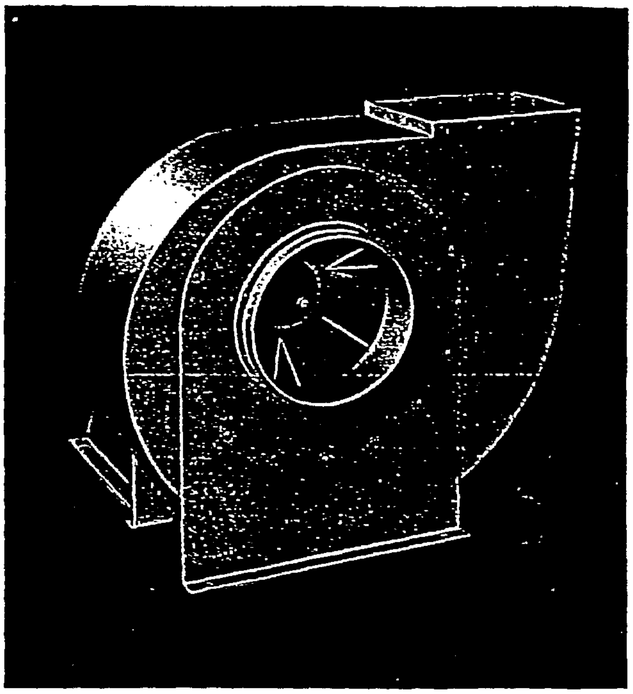


Fig. 1—AAF Type K exhauster, Size 21, Arrangement 1, designed to handle from 5000 to 12000 cfm at static pressures from 1" to 16" wg.

The taper lock hub used on sizes 13 through 42 puts an end to impellers freezing to shafts. The same principle is incorporated in this hub design as is used on taper lock hubs for V-belt drives. This hub design has proved its merit in thousands of installations of AAF exhaust equipment operating under the most severe conditions of corrosion, abrasion, and temperature. This is an exclusive feature of the Type K exhauster.

SPECIAL ALLOY STEELS — Type K exhausters can be constructed of stainless steel, monel, or other special alloys.

NON SPARKING WHEELS — Everdur or aluminum wheels are available to meet applications involving explosion hazards.

ACCESSORIES

ACCESS DOORS: Specially designed quick opening access doors can be incorporated on all exhauster sizes and are recommended for all applications handling heavy dust loads. The quick release handles on these doors make the inside of the fan readily available for inspection and cleaning.

HOUSING DRAINS: Fan housing drains should be included in all exhausters where moisture may condense and accumulate at the low point in the fan housing or where rain may enter the fan discharge during shutdown.

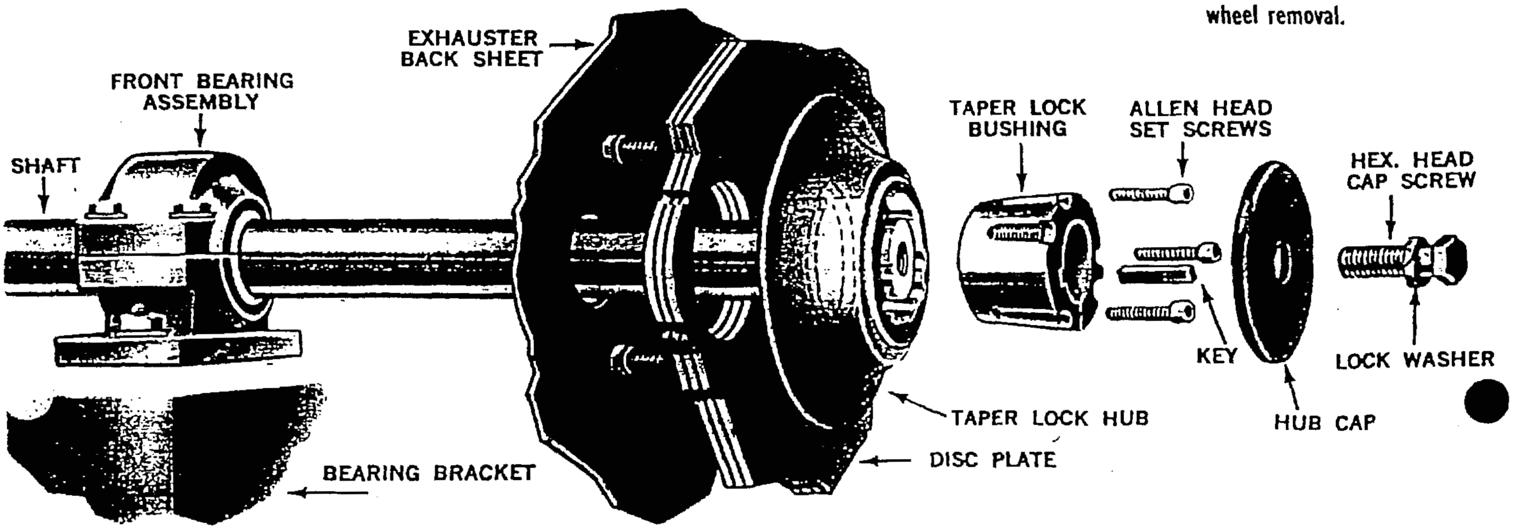
FLANGED INLET & OUTLET: Flanges for both the fan inlet and outlet can be furnished, on all Type "K" Exhausters, to make fan installation easier. Ductwork can be installed prior to receiving the fan, since no sleave connections are required.

COOLING DISC: A cooling disc is recommended, to protect bearings from 600°F and 700°F. Consult your nearest AAF field office to obtain information on the type of special construction required for temperatures in excess of 700°F.

SHAFT SEAL: Air leakage around the fan shaft is prevented by incorporating a shaft seal. Shaft seals are available for both high and low temperature applications.

Construction details of Type K Exhauster shaft assembly for sizes 13 through 42 showing heavy duty bearings, oversized shaft, and cast iron hub with taper lock for easy wheel removal.

SHAFT ASSEMBLY



CAPACITIES

Type K exhausters are available in eleven sizes ranging from 7-inch to 42-inch inlet diameter. Corresponding wheel diameters range from 12.0″ to 69 inches.

Available capacities range from 300 to 52,000 CFM at static pressures to 16 inches of water (and higher where tip speed allows or in special construction.)

DIMENSIONS

Type K exhauster dimensions are shown on page 19. Arrangement nine dimensions are essentially the same as for arrangement one shown. Certified prints will be submitted for arrangements 4, 8 and 9 after determination of motor size to be mounted on unit.

ARRANGEMENTS

Standard AMCA arrangements 1, 4, 8 and 9 are available. ARRANGEMENT ONE is predominately used for the usual industrial exhaust system. Where space is at a premium ARRANGEMENT NINE should be considered. ARRANGEMENT FOUR is a direct drive unit in which the motor bearings take the wheel load. ARRANGEMENT EIGHT is a direct drive unit with the motor driving the fan through a flexible coupling. Fan shaft is supported separately from motor on two bearings.

CONSTRUCTION DETAILS

HOUSING CONSTRUCTION: Heavy gage all-welded housings with unique winged rib design, used for many years in AAF Type W ROTO-CLONES, have been incorporated in the Type K exhauster. This design reinforces the exhauster back plate to eliminate housing deflection and distortion under high operating pressures.

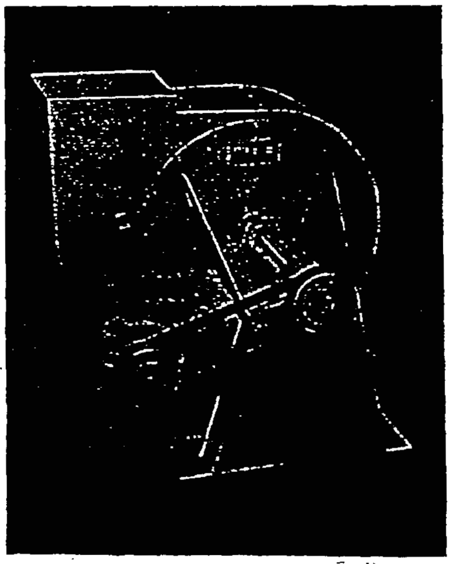


Fig. 2.—Arrangement 9 recommended where space is at a premium.

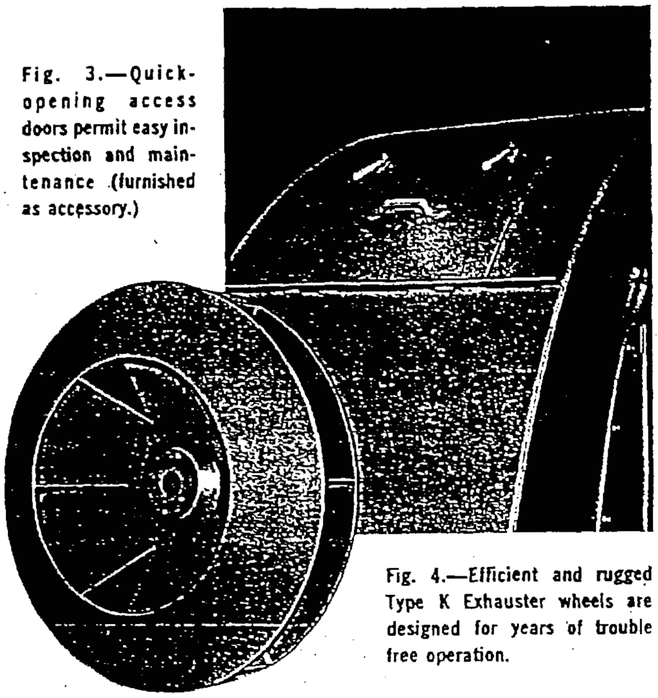


Fig. 3.—Quick-opening access doors permit easy inspection and maintenance (furnished as accessory.)

Fig. 4.—Efficient and rugged Type K Exhauster wheels are designed for years of trouble free operation.

BEARINGS: Heavy duty ball grease bearings are standard on Type K exhausters. Bearings have been selected for extra long life under the most severe operating conditions. Bearings are self-aligning with provisions for expansion included. Other bearing types can be furnished to meet special operating conditions where required.

HIGH TEMPERATURE UNITS: Type K exhausters of standard construction are used for operations with air temperatures up to 400° F. For temperatures from 400 to 700° F, units will be provided with oil lubricated ball bearings. Special heat slingers are incorporated with the oil lubricated bearings for temperatures from 600° F to 700° F. Consult your nearest AAF Field Office for the maximum allowable fan speed when the air temperature exceeds 600° F, and for the special construction required when temperatures exceed 700° F.

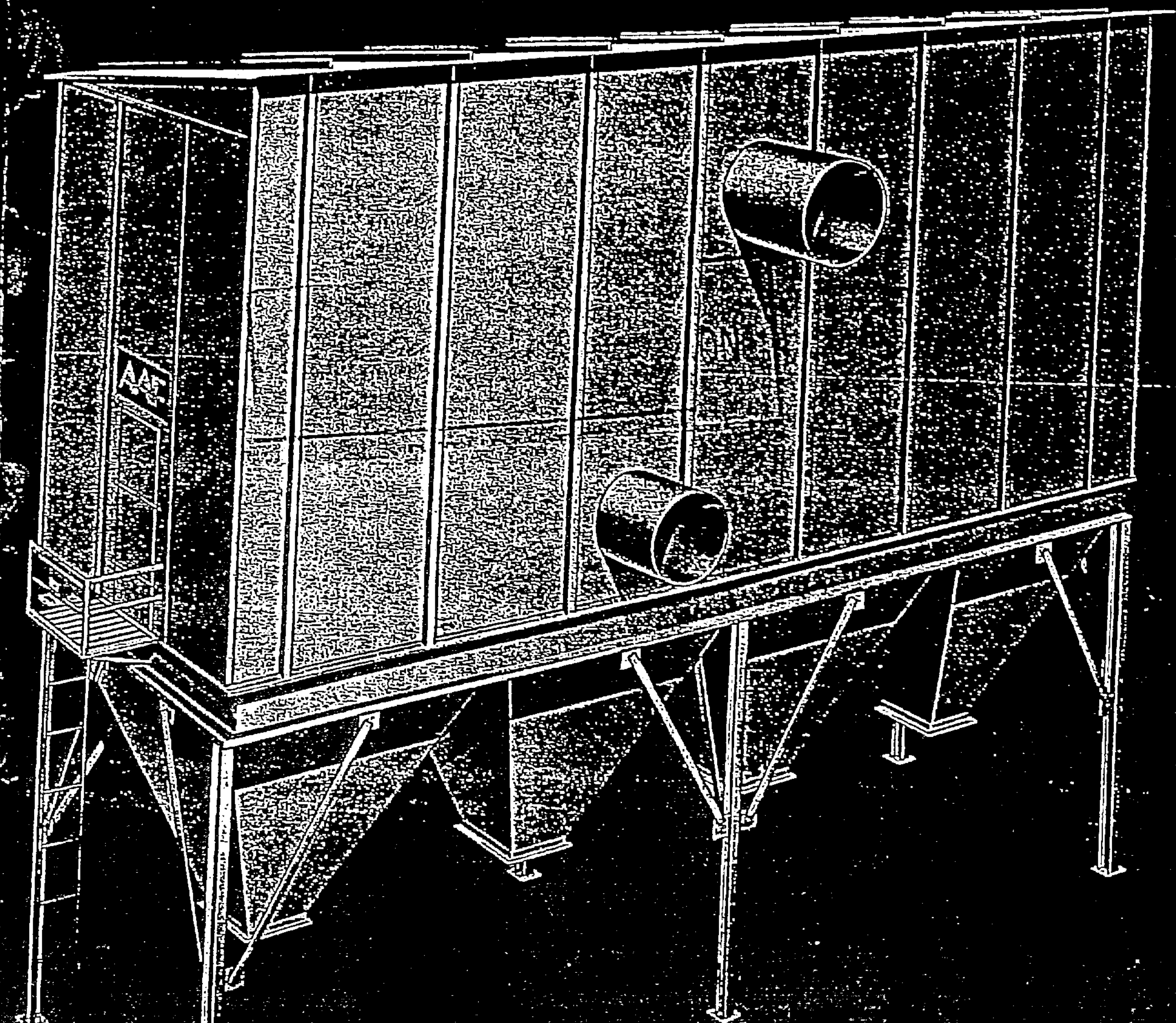
SPECIAL CONSTRUCTION

RUBBER LINING — can be furnished where service conditions require. Maximum tip speed should be reduced 15 per cent for this construction.

CORROSION RESISTANT COATINGS — can be furnished as specified.

BULLETIN NO. [illegible]

AMER-*tube* DUST COLLECTOR



Cloth-tube dust collector with electrically operated shaker mechanism. Available for both intermittent and continuous automatic operation in a wide range of capacities.

American Air Filter

BETTER AIR IS OUR BUSINESS

Member

I G C I

industrial gas cleaning institute, inc.

CAPACITIES

Capacities for each standard size AMER-tube Collector are shown in the chart below. Dimensions are over-all. For sizes other than standard, consult American Air Filter.

INTERMITTENT TYPE AMER-tube COLLECTORS

Size No.	No. Bags	Cloth Area Sq. Ft.	Estimated Net Wt.	Shaker Motors No.	Shaker Motors Size	No. of Hoppers
46	96	1334	3950	1	¾ HP	1
56	120	1668	4195	1	1 HP	1
66	144	2002	4500	1	1 HP	1
76	168	2335	5005	1	1½ HP	1
86	192	2669	5510	1	1½ HP	1
96	216	3002	6015	1	1½ HP	1
106	240	3336	6520	1	2 HP	2
116	264	3670	7025	1	2 HP	2
126	288	4003	7530	1	2 HP	2
136	312	4337	8135	2	1½ HP	2
146	336	4670	8640	2	1½ HP	2
156	360	5004	9145	2	1½ HP	2
166	384	5338	9645	2	1½ HP	2
176	408	5671	10155	2	1½ HP	2
186	432	6005	10660	2	1½ HP	2
196	456	6338	11165	2	1½ HP	3
206	480	6672	11670	2	2 HP	3
216	504	7005	12175	2	2 HP	3
226	528	7339	12680	2	2 HP	3
236	552	7773	13185	2	2 HP	3
246	576	8006	13690	2	2 HP	3
256	600	8340	14295	3	1½ HP	3
266	624	8674	14800	3	1½ HP	3
276	648	9007	15305	3	1½ HP	3
286	672	9341	15810	3	2 HP	4
296	696	9674	16315	3	2 HP	4
306	770	10703	16820	3	2 HP	4

CONTINUOUS AUTOMATIC AMER-tube COLLECTORS

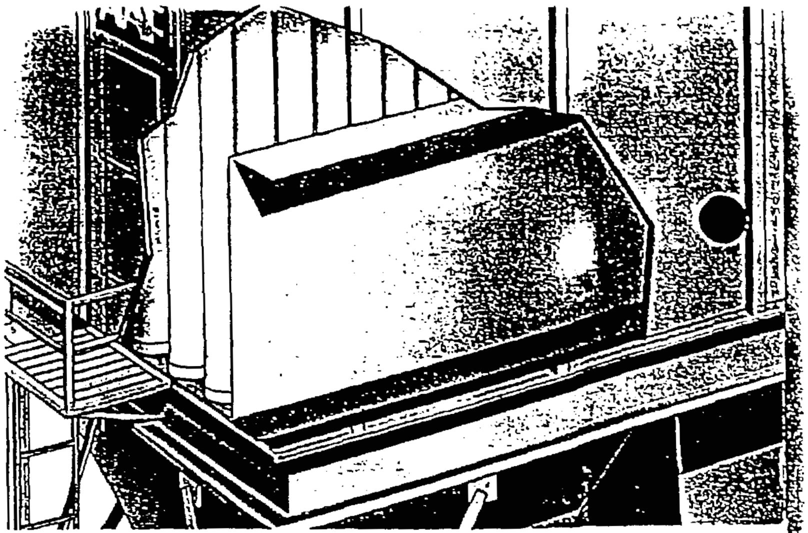
Size No.	Two Compartment No. Bags	Two Compartment Net Cloth Area*	Three Compartment No. Bags	Three Compartment Net Cloth Area*	Four Compartment No. Bags	Four Compartment Net Cloth Area*
46	192	1,334	256	2,501	360	3,668
56	240	1,668	348	3,169	456	4,670
66	288	2,002	420	3,837	552	5,672
76	336	2,335	492	4,503	648	6,671
86	384	2,669	564	5,171	744	7,673
96	432	3,002	636	5,837	840	8,672
106	480	3,336	708	6,505	936	9,674
116	528	3,670	780	7,173	1,032	10,676
126	576	4,003	852	7,839	1,128	11,675

*[illegible]

AMER-*tube*

FABRIC DUST COLLECTOR

- High cleaning efficiency
- Simple operation
- Rugged construction
- Infrequent maintenance by non-skilled personnel
- Effective, durable bag cleaning mechanism
- Wide choice of filter fabrics



Cut-away view showing inlet baffle.

The AAF AMER-tube dust collector is a moderately priced unit for filtering fine dust and fume from contaminated air or gases. Nearly any non-hygroscopic, solid particulate matter may be efficiently removed at gas temperatures above the condensation point.

Dust-laden air enters the AMER-tube collector through a built-in, baffled distribution plenum which eliminates high-velocity air currents and provides maximum protection against abrasion of bags and metal surfaces.

Intermittent type units are designed for use on light industrial duty applications, or on those applications where the system exhauster can be shut down periodically to clean the bags.

Continuous automatic units are designed for use on heavy duty dust collection applications where the dust producing source must operate for extended periods of time without interruptions. This type of collector is di- ided into compartments in such a way that one compart- ment at a time can be automatically shut down and the tubes shaken to remove the collected dust deposit. During this cleaning cycle, the remaining compartments continue to filter the total system air volume.

AMER-tube CONSTRUCTION FEATURES

Hoppers are 60° side slope, all-welded 14 gauge metal with inspection plate and suitable stiffeners. Flanged discharge opening is 7″ x 7″. Housing and roof panels are 14 gauge metal, punched and flanged for bolted, gasketed connections. An 18″ x 48″ access door is located at one end of the collector.

Hoppers, tube sheets and wall panels bolt to 18″ deep formed channel base frame. Internal walkway is 18″ wide with six rows of bags on each side.

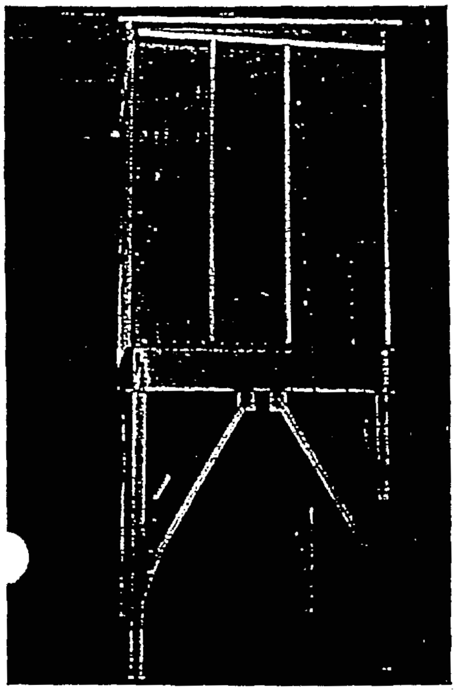
Filter bags are shaken by oscillating tubular hangers, electrically driven through eccentrics and connecting rods located above the walkway. Coarse particles settle directly into the hoppers. Bags are cleaned gently but effectively. All moving parts may be located outside the housing at extra cost. Rugged, maintenance-free components are standard.

Filter bags are 5″ diameter x 10′ 6″ long, fabricated to rigid quality standards. Bag tension is readily adjusted without tools. A wide variety of natural and synthetic filter fabrics is available as well as special fabric finishes.

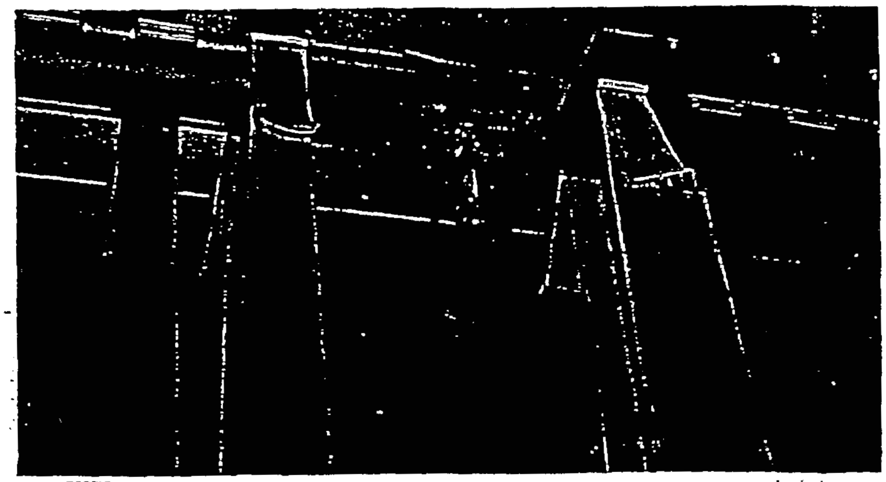
Supports are heavy rolled shapes with suitable braces and gusset plates. Standard height provides 4′0″ clearance beneath hopper flanges. Truck clearance (8′0″) supports are available at extra cost. Included with the purchase of support members is the necessary number of access platforms and ladders.

Accessories, such as dampers, timers, and rotary locks are of superior design and rugged construction.

AMER-tube collectors are shipped knocked-down for field erection by others. In smaller sizes, they can be partially shop-erected and shipped in sub-assemblies at extra cost.



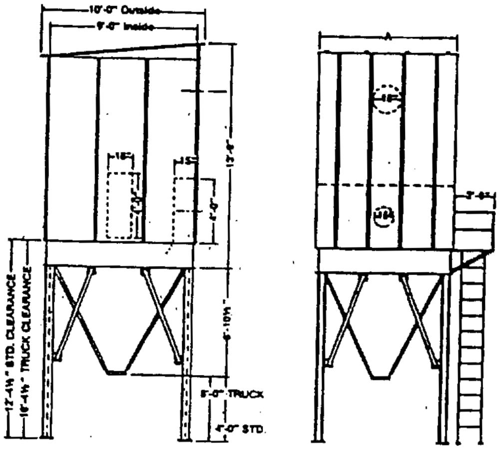
AAF cloth-tube collector, intermittent type, capacity 12,000 cfm.



AMER-tube shaker mechanism illustrating one bag-support tube and method of bag attachment.

DIMENSIONS

INTERMITTENT TYPE AMER-tube COLLECTOR



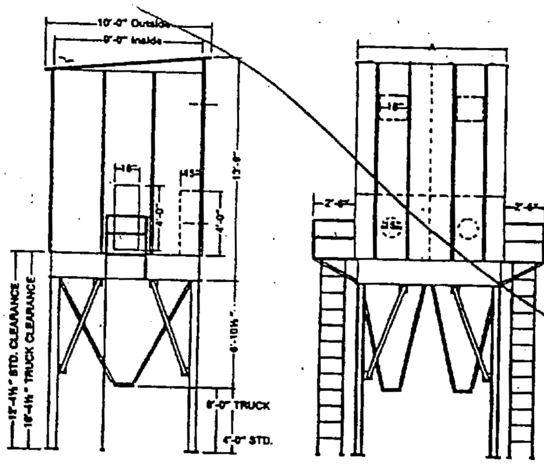
SIZE	NUMBER HOPPERS	A*
46	1	4'-6½
56	[illegible]	5'-6½
66	1	6'-6½
76	1	[illegible]
86	[illegible]	[illegible]
96	2	[illegible]
106	2	10'-6½
116	2	[illegible]
126	2	12'-6½
136	2	[illegible]
146	2	[illegible]
156	2	[illegible]
166	2	16'-6½
176	2	[illegible]
186	2	[illegible]

*Inside.

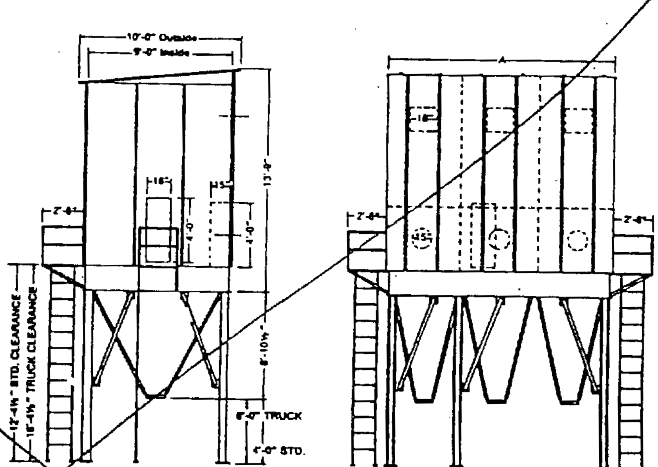
SIZE	NUMBER HOPPERS	A*
196	[illegible]	[illegible]
206	[illegible]	[illegible]
216	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
246	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
276	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
306	[illegible]	[illegible]

*Inside.

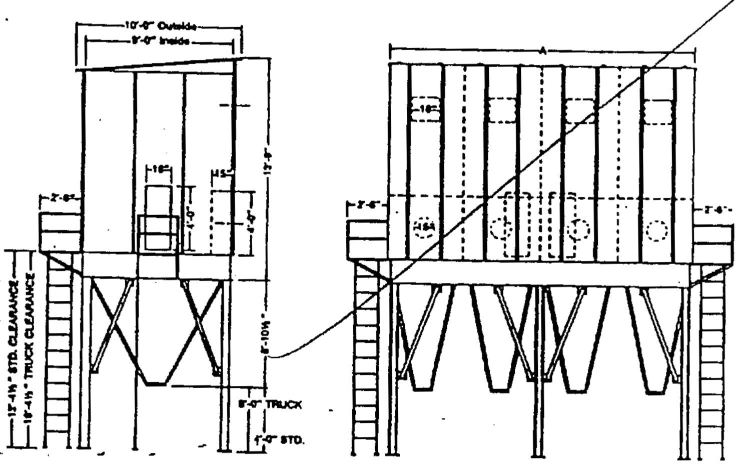
CONTINUOUS AUTOMATIC AMER-tube COLLECTOR



Two Compartment



Three Compartment



Four Compartment

2-Compartment

SIZE	NUMBER HOPPERS	A*
[illegible]	[illegible]	[illegible]

*Inside.

3-Compartment

SIZE	NUMBER HOPPERS	A*
[illegible]	[illegible]	[illegible]

*Inside.

4-Compartment

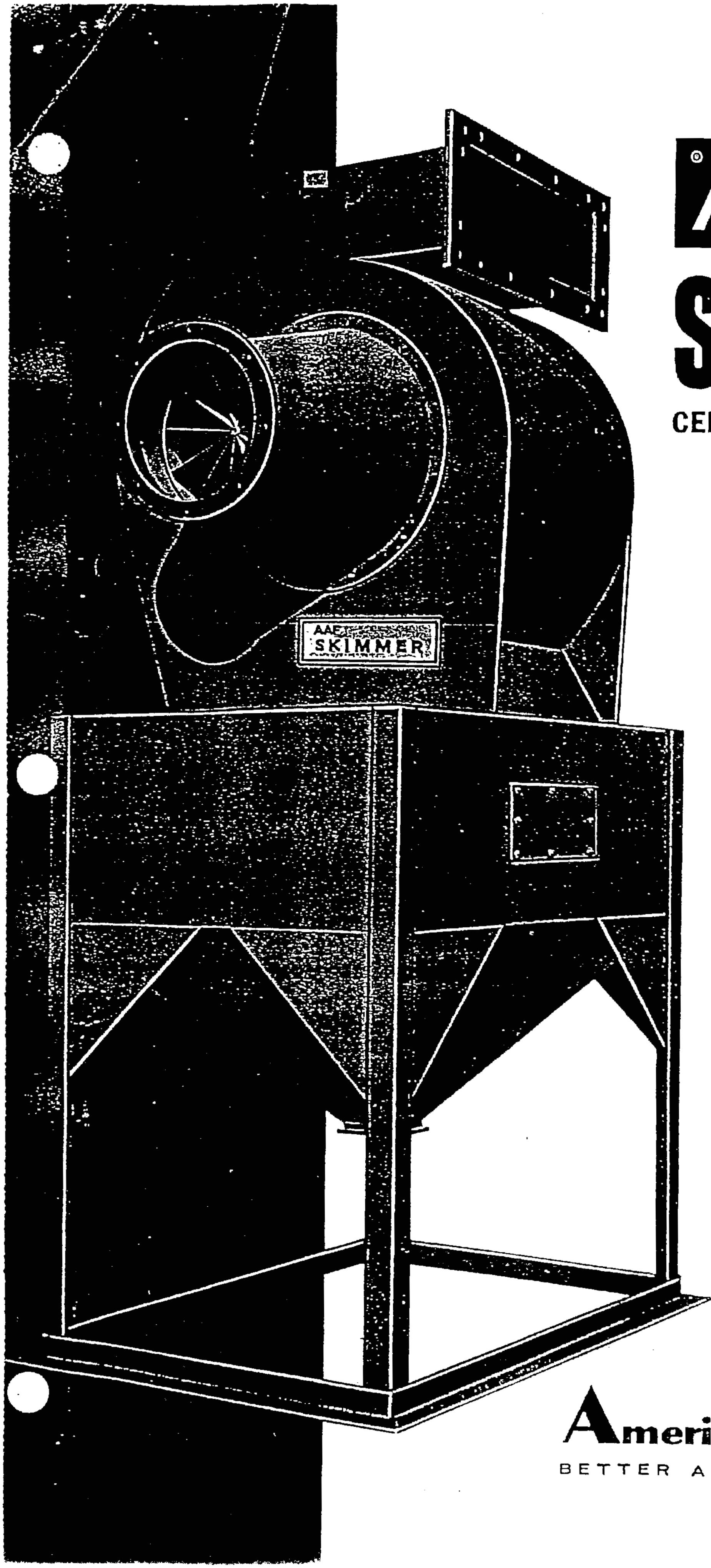
SIZE	NUMBER HOPPERS	A*
[illegible]	[illegible]	[illegible]

*Inside.

AAF American Air Filter
COMPANY, INC., LOUISVILLE, KENTUCKY

In Canada: American Air Filter of Canada, Ltd.
400 Stinson Blvd., Montreal 9

DUST CONTROL
BULLETIN NO. 276-C



AAF

SKIMMER

CENTRIFUGAL PRECIPITATOR

SIZE 27

Member
IGCI
Industrial gas cleaning institute, Inc.

American Air Filter
BETTER AIR IS OUR BUSINESS

AAF SKIMMER PROVIDES THESE OUTSTANDING ADVANTAGES

REQUIRES LESS SPACE. The AAF Skimmer requires 50% less space than other low-pressure-drop centrifugals. Conventional cyclones normally require the length of the conical sections to be twice the diameter of the barrel for proper collection efficiency. The unique design of the AAF Skimmer saves this space by eliminating this cone and collecting the dust through slots along the periphery of the wrapper sheet.

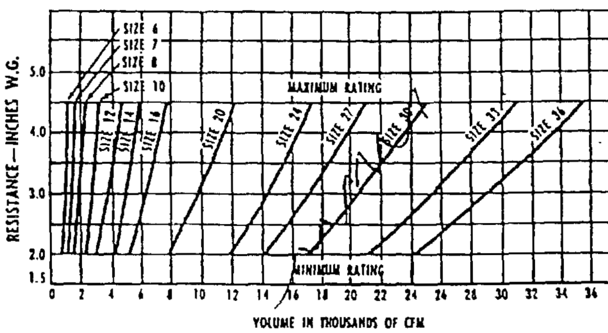
COMBINES SUPPORT STAND AND STORAGE BIN. The AAF Skimmer hopper is a compact support stand and dust storage bin. The 12" x 12" hopper outlet will readily accommodate most devices for dust removal. The large storage capacity of the hopper permits extended operation before dust removal is required. Capacity in cubic feet for all hoppers is shown on page 4. Where airtight storage bin or hopper is available, the AAF Skimmer can be furnished without the standard hopper.

PROVIDES COMPLETE ACCESS TO INTERIOR. A quick opening access door mounted on the side opposite the outlet provides complete access to all interior surfaces of the Skimmer. In addition an access door is mounted on the side of the hopper to provide inspection. Therefore, any accumulations or bridging caused by condensation or foreign material can be quickly and easily removed.

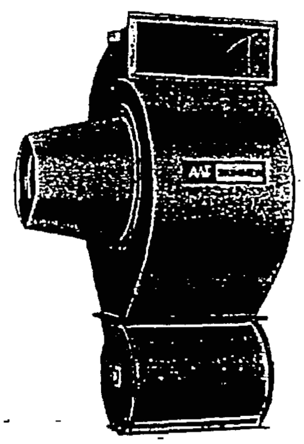
PERMITS CLOSE COUPLING TO AIR MOVER. All exhausters require good entrance conditions to achieve optimum "air moving efficiency." In fan terminology, this means "filling the wheel" rather than having poor air distribution over the fan inlet area. The incorporation of straightened vanes or rosettes changes the air movement pattern in the AAF Skimmer from radial or tangential to straight flow. This permits close coupling of the air mover to the Skimmer without the need of expensive, space-requiring duct work. Complete dimensions of AAF Skimmer and exhauster combination will be furnished on request.

AVAILABLE IN 13 SIZES. Collection efficiency in any centrifugal dust collector is a function of the velocity creating the interior centrifugal forces. The higher the velocity, the higher the centrifugal force with resulting higher efficiency. Conversely any reduction in velocity means decreased efficiency. AAF, recognizing this elementary principle, has available 13 sizes of the AAF Skimmer. Air volumes range from 600 to 36,000 cfm.

CAPACITY—RESISTANCE CURVE

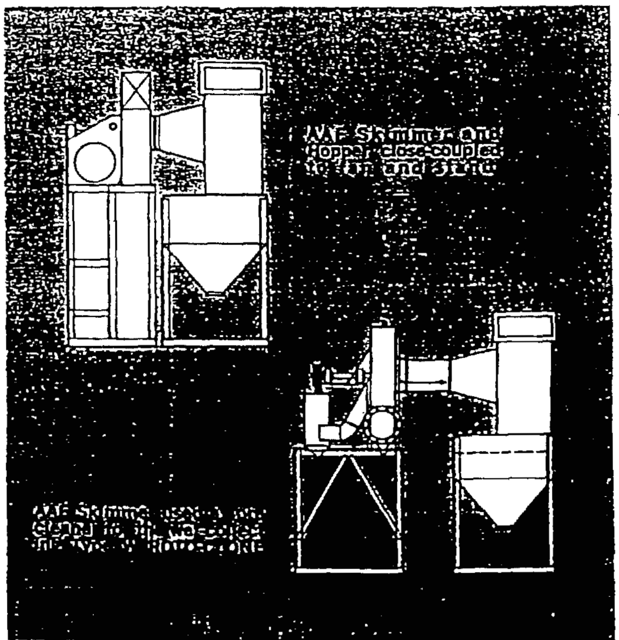


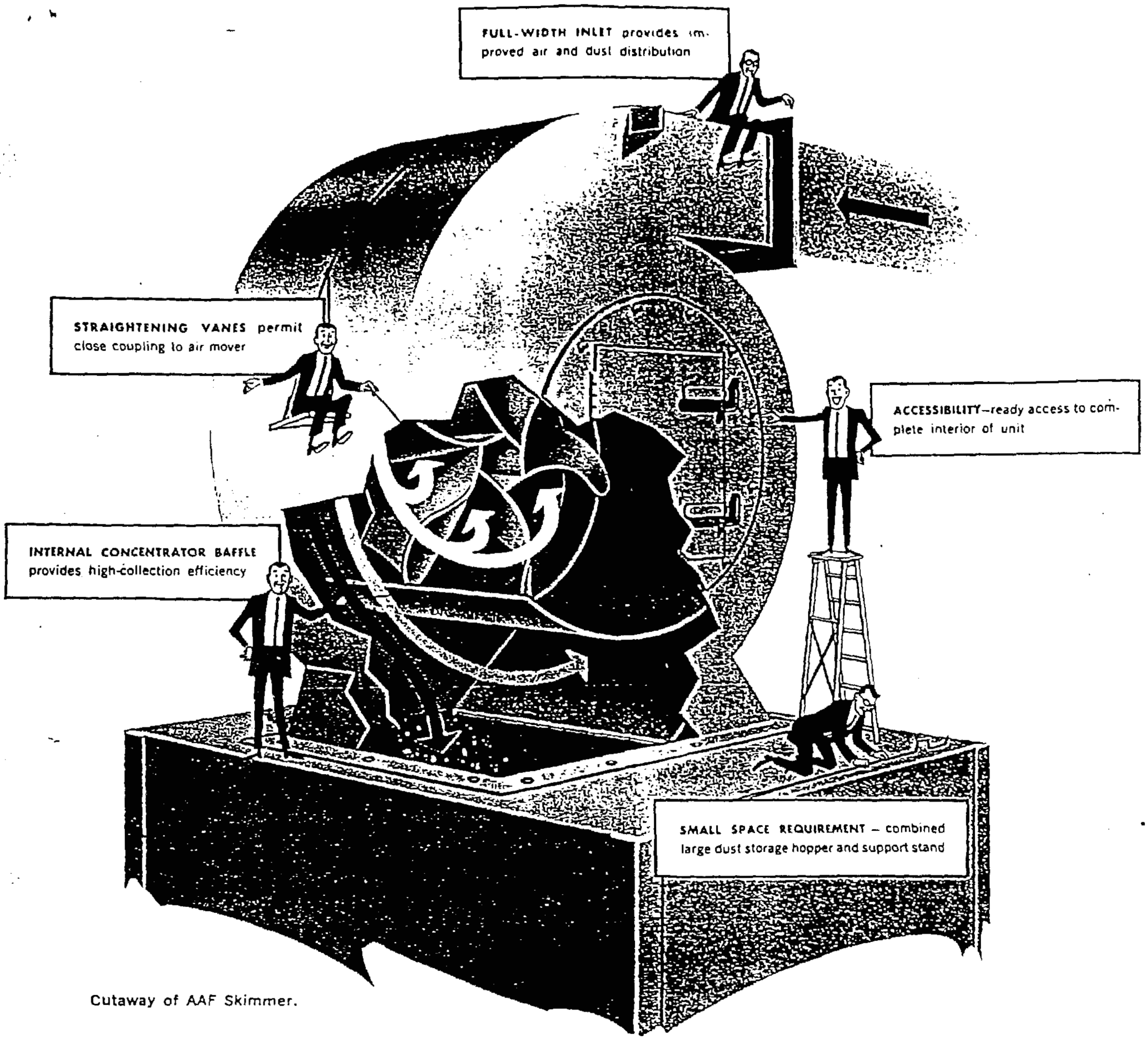
SIZE 27



FOR SPECIAL APPLICATIONS

Where large quantities of bulky materials are collected, the AAF Skimmer is often used with a special device for continual dust disposal (in place of the standard hopper). This particular arrangement has proven particularly successful for applications such as the collection of tobacco-leaf and wood shavings.





Cutaway of AAF Skimmer.

THE AAF SKIMMER is a low-pressure-drop centrifugal precipitator. Dust laden air enters the AAF Skimmer tangentially. Centrifugal forces, created by this inlet, compel the dust particles to follow the involute curve of the wrapper sheet. The bulk of the dust is skimmed from the air stream through a wide slot. The remaining dust enters the unique secondary air system within the unit and is blended with incoming dust-laden air. This secondary system, with its continual cyclonic force, eventually deposits most of the dust through the slot into the storage hopper. Cleaned air is exhausted to the atmosphere or, in many cases, to a secondary cleaner. Clockwise and counterclockwise inlets are available. Pressure loss through the AAF Skimmer is 2 Velocity Pressures, based on air velocity at the inlet.

The AAF Skimmer is used for

- Primary collectors in pneumatic conveying
- Primary collectors where atmospheric pollution will not be created.
- Reduction of dust loading to more efficient final collector.
- Reclamation of the large size fraction of the dust in a dry state where wet collectors are used.

Straightening vanes in outlet of AAF Skimmer.

AAF SKIMMER DIMENSIONS

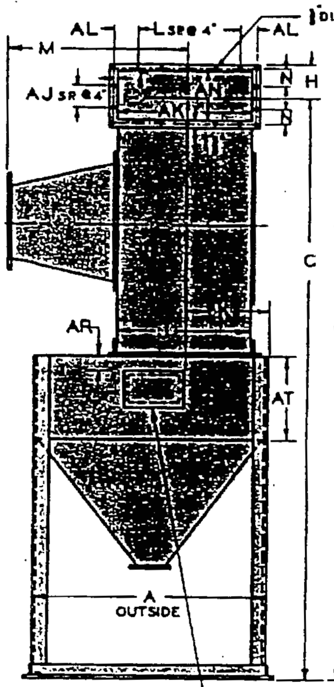


FIG. 1

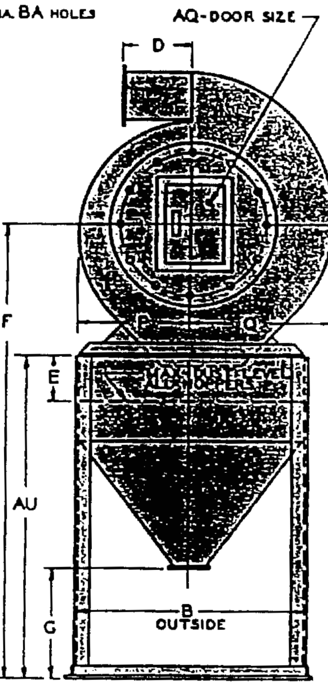


FIG. 2

SIZES #6 THRU #10, 8" x 10" DOOR
SIZES #12 & #14, 10" x 14" DOOR
SIZES #16 THRU #36, 16" x 20" DOOR

SIZE	6	7	8	10	12	14	16	20	24	27	30	33	36
A	2'-8½"	2'-2½"	2'-2½"	3'-4½"	3'-0½"	4'-6½"	4'-2½"	5'-2½"	6'-9"	7'-9½"	7'-9½"	9'-2½"	9'-2½"
B	18½"	2'-2½"	2'-2½"	2'-2½"	3'-0½"	3'-0½"	3'-8½"	3'-8½"	4'-9"	7'-9½"	7'-9½"	9'-2½"	9'-2½"
C	6'-9½"	7'-9½"	8'-0½"	8'-4½"	10'-7½"	11'-2½"	12'-3½"	12'-10"	14'-7½"	16'-5½"	17'-3½"	18'-9½"	19'-7½"
D	7"	8"	9"	10"	11"	12"	12"	12"	12"	18"	18"	18"	18"
E	7"	8"	8"	9"	10"	11"	12"	12"	15"	15"	15"	15"	15"
F	5'-11½"	6'-9½"	6'-11½"	6'-11½"	8'-10½"	9'-3"	10'-0½"	10'-0½"	11'-3"	12'-7"	13'-1"	14'-2"	14'-8"
G	18"	18"	18"	18"	24"	24"	24"	24"	24"	24"	24"	24"	24"
H	3½"	3½"	4½"	5½"	5½"	6½"	6½"	8½"	9½"	10½"	11½"	12½"	13½"
J	10½"	12½"	14½"	17½"	21½"	24½"	2'-4½"	2'-11½"	3'-5½"	3'-11"	4'-4½"	4'-9"	5'-2½"
K	15½"	8½"	9½"	15½"	12½"	16½"	16½"	19½"	3'-4½"	2'-2½"	2'-4½"	2'-7½"	2'-10"
L	2	2	3	4	4	5	6	7	9	11	12	13	15
M	14½"	17"	19½"	24½"	2'-4½"	2'-0½"	3'-2½"	3'-11"	4'-0½"	5'-4½"	5'-11½"	6'-6½"	7'-1½"
N	2½"	3½"	1½"	2½"	2½"	1½"	2½"	3½"	2½"	1½"	2½"	1½"	3½"
P	9"	10½"	12"	15"	18"	21"	24"	2'-6"	3'-0"	3'-4½"	3'-9"	4'-1½"	4'-6"
Q	11½"	13½"	15½"	19½"	22½"	2'-2½"	2'-6½"	3'-1½"	3'-9½"	4'-3"	4'-8½"	5'-1½"	5'-7½"
R	1½"	1½"	1½"	1½"	1½"	1½"	1½"	1½"	1½"	2½"	2½"	2½"	2½"
S	10	12	14	16	20	20	26	26	34	44	50	54	56
T	2"	2"	2"	2"	3"	3"	3"	3"	3"	4"	4"	4"	4"
U	14"	19½"	19½"	22"	2'-6½"	2'-8"	3'-4"	3'-4"	4'-4"	6'-7½"	7'-4½"	8'-1½"	8'-9½"
V	10½"	12½"	14"	18½"	21"	24½"	2'-4"	2'-11½"	3'-6"	3'-11½"	4'-4½"	4'-9½"	5'-3"
W	21"	2'-5"	2'-5"	2'-5"	3'-4½"	3'-4½"	4'-0½"	4'-0½"	5'-0½"	8'-2½"	8'-2½"	9'-7½"	9'-7½"
X	—	—	—	—	—	—	—	—	3'-6½"	4'-1½"	4'-1½"	4'-9½"	4'-9½"
Y	2'-11"	2'-5"	2'-5"	3'-7"	3'-4½"	4'-10½"	4'-6½"	5'-6½"	7'-0½"	8'-2½"	8'-2½"	9'-7½"	9'-7½"
Z	4	4	4	4	4	4	6	6	6	6	6	6	6
AA	11/16"	13/16"	11/16"	11/16"	11/16"	15/16"	15/16"	15/16"	15/16"	15/16"	13/16"	15/16"	15/16"
AB	16½"	22"	22"	24½"	2'-9"	2'-10½"	3'-6½"	3'-6½"	4'-6½"	6'-0"	7'-7"	8'-4"	9'-0"
AC	12½"	14½"	16½"	19½"	23½"	2'-2½"	2'-6½"	3'-1½"	3'-8½"	4'-1½"	4'-6½"	5'-0"	5'-5½"
AD	2½"	2"	2"	½"	1½"	2½"	½"	3½"	½"	2"	½"	2"	3"
AE	2	3	3	4	5	5	7	6	9	13	15	16	17
AF	3½"	4½"	2½"	3½"	2½"	4½"	3½"	3½"	4½"	3½"	3½"	3"	2½"
AG	1	1	2	2	3	3	4	5	6	7	8	9	10
AH	1½"	1½"	1½"	½"	1½"	1½"	1½"	½"	1½"	1½"	1½"	1½"	1½"
AJ	—	—	1	1	1	2	2	2	3	4	4	5	5
AK	10½"	12½"	14"	17½"	21"	24½"	2'-4"	2'-11"	3'-5½"	3'-10½"	4'-3½"	4'-9"	5'-2½"
AL	2½"	3"	1½"	1½"	3½"	3½"	2½"	4½"	3½"	2½"	2½"	3½"	2"
AM	6	6	6	8	8	8	8	12	12	12	12	16	16
AN	4"	4½"	5½"	7"	8"	9½"	10½"	13"	15½"	17½"	19½"	21½"	24½"
AQ	—	8" x 10"	10" x 11"	12" x 13"	14" x 16"	16" x 19"	16" x 19"	19" x 27"	19" x 27"	19" x 27"	19" x 27"	19" x 27"	19" x 27"
AR	2 7/8"	3 1/8"	3 1/8"	3 1/8"	3 13/16"	3 13/16"	5 1/4"	5 1/8"	11"	12 7/16"	12 7/16"	12 3/16"	12 3/16"
AT	2'-3 1/8"	2'-5 7/8"	2'-3 7/8"	2'-5 7/8"	2'-11 7/8"	2'-11 5/8"	3'-5 1/8"	3'-5 1/8"	2'-4 7/8"	2'-6"	2'-6"	2'-6"	2'-6"
AU	5'-0"	5'-8"	5'-8"	5'-8"	7'-0"	7'-0"	7'-6"	7'-6"	7'-6"	8'-7"	8'-7"	9'-4"	9'-4"
CAP. CU. FT.	10.5	13.1	13.1	18.6	27.7	39.2	50.2	61.6	72.9	163.3	163.3	248.7	248.7
AV	2¼	2¼	2¼	2¼	3¼	3¼	3¼	3¼	3¼	4¼	4¼	4¼	4¼
AW	2'-8¼"	2'-2¼"	2'-2¼"	3'-4¼"	3'-0¼"	4'-6¼"	4'-2¼"	5'-2¼"	6'-8¼"	7'-9"	7'-9"	9'-2"	9'-2"
AX	2'-10½"	2'-4½"	2'-4½"	3'-6½"	3'-3¼"	4'-9¼"	4'-5¼"	5'-5¼"	6'-11¼"	8'-2"	8'-2"	9'-7"	9'-7"
AY	20½"	2'-4½"	2'-4½"	2'-4½"	3'-3¼"	3'-3¼"	3'-11¼"	3'-11¼"	4'-11¼"	8'-2"	8'-2"	9'-7"	9'-7"
AZ	15⅛"	8⅛"	9⅛"	14⅛"	12⅛"	16⅛"	16⅛"	19⅛"	3'-4⅛"	2'-1¼"	2'-4⅛"	2'-7"	2'-9⅛"
BA	12	12	16	18	18	22	24	26	32	38	40	44	48
BB	9⅛	10⅛	11⅛	13⅛	15⅛"	17⅛"	20⅛	24⅛	2'-4⅛	2'-7⅛	2'-10⅛	3'-1⅛	3'-4⅛
BC	6"	7"	8"	10"	12"	14"	16"	20"	24"	2'-3"	2'-6"	2'-9"	3'-0"
BD	6	6	6	8	8	8	8	12	12	12	12	16	16
BE	7⅝"	8⅝"	9⅝"	11⅝"	14"	15¾"	18⅜"	22½"	2'-2⅛"	2'-5⅜"	2'-8⅜"	2'-11¾"	3'-2⅜"
BF	30°	30°	30°	22½°	22½°	22½°	22½°	15°	15°	15°	15°	11¼°	11¼°

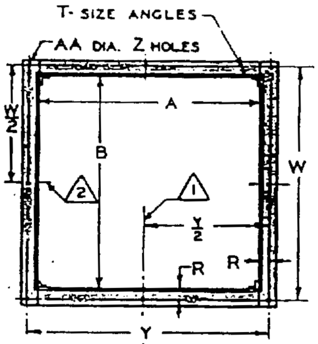
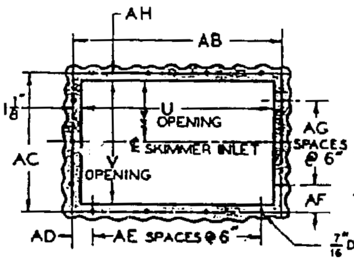


FIG. 3 - BASE DRILLING FOR FIG. 1



$\frac{7}{16}$" DIA. S HOLES

FIG. 4 - BASE DRILLING FOR SKIMMER ONLY

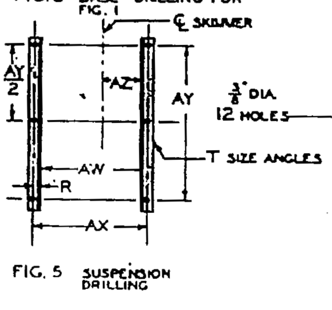


FIG. 5 SUSPENSION DRILLING

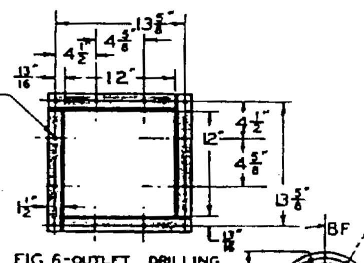


FIG. 6 - OUTLET DRILLING TYPE S HOPPER

FIG. 9 SKIMMER OUTLET DRILLING

$\frac{1}{2}$ DIA. BD HOLES EQUALLY SPACED ON BE DIA. BC.

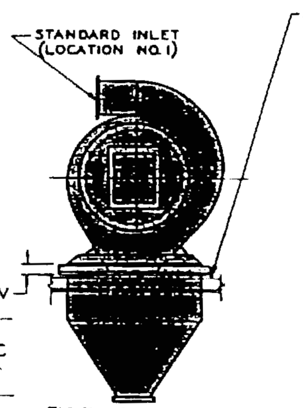


FIG. 7 - ARRANGEMENT FOR CEILING SUSPENSION

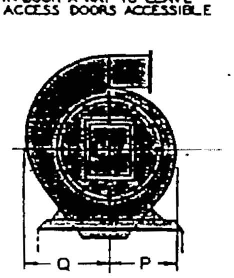


FIG 8 - ALTERNATE INLET (LOCATION NO. 2) PROVIDED ONLY WHEN SPECIFIED

NOTES:

⚠1 HOLES THIS ℄ FOR SIZES #24 THRU #36.

⚠2 HOLES THIS ℄ FOR SIZES #16 & #20.

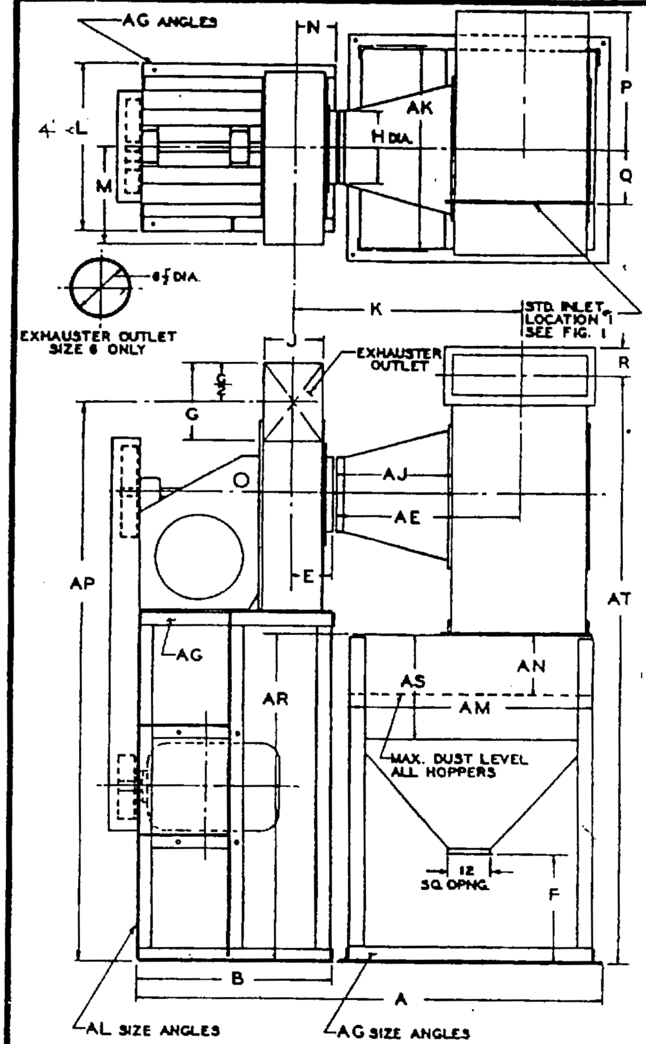
AAF American Air Filter
COMPANY, INC., LOUISVILLE, KENTUCKY

In Canada: American Air Filter of Canada, Ltd.
400 Stinson Blvd., Montreal 9

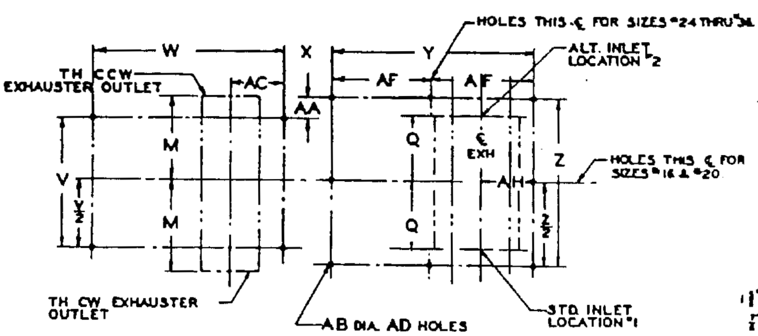
76-C - 5M - 1-64 - Reprinted 10M - 3-65 - CP

ITEM NO. 330

REVISIONS			
© REVISED FOR MODEL "B" SKIMMER LC 3-17-61			



SIZE	6	7	8	10	12	14	16	20	24	27	30	33	36
EXH.	6B	860N	860N	861N	13K	15K	17K	21K	23K	26K	30K	34K	38K
A	4-8	4-2	4-2	5-7	6-4	6-4	6-3	9-11	12-7	13-6	14-3	16-1	17-0
B	18	16	16	22"	2-8	3-3	3-8	4-0	4-2	4-11	5-8	6-2	6-10
C	15	8	8	15	12	16	16	19	3-4	2-2	2-4	2-7	2-10"
D	10"	12	14"	17	21"	24	2-4"	2-11"	3-5	3-10	4-3	4-9"	5-2
E	3	5	5	6	7	8	9	10	11	12	14	16"	17
F	18"	18"	18"	18"	24"	24"	24"	24"	24"	24"	24"	24"	24"
G		8	8	10	13	15	17	21	23	2-2	2-6	2-10	3-2
H	6	9"	9"	11"	13"	15"	17"	21"	23"	2-2"	2-6"	2-10"	3-2"
J		7	7	9	10	11	13	16	17	20	23	2-2	2-5
K	2-1	24	23	2-8	3-0	4-2	4-0"	4-8	5-8	7-2	7-2	8-5	8-7
L	20"	19	19	22	2-8	2-10	2-11	3-5	3-7	4-0	4-0	4-5	4-10
M	9	10	10	12	14	16	19"	23"	2-1	2-4"	2-8	3-0	3-4
N	5	3	3	4	8	9"	9	11	12	14"	16	17	19
P	11	13	15	19	22	2-2	2-6	3-1	3-9	4-3"	4-6	5-1	5-7
Q	7"	8"	9"	10"	11"	12"	12"	12"	12"	16"	16"	16"	16"
R	3	3	4	5	5	6	6	8	9	10	11	12	13
S	2	3"	1	1	3	3	2	4	3	2	2"	3	2"
T	2	2	3	4	4	5	6	7	9	11	12	13	15
U			1	1	1	2	2	2	3	4	4	5	5
V	18	18"	18"	21"	2-3	2-7	2-9	3-3	3-5"	3-9	3-9	4-2	4-7
W	14	14	14	18"	2-4	2-11	3-1	3-8	3-10	4-7	5-4	5-10	6-6
X	3	3	3	3	4	3	4"	5"	17"	4	4	4	7"
Y	2-11"	2-5"	2-5"	3-7"	3-4	4-10	4-6	5-6	7-0	8-2	8-2	9-7	9-7
Z	21"	2-5"	2-5"	2-5"	3-4	3-4	4-0	4-0	5-0	8-2	8-2	9-7	9-7
AA	1	5	5	4"	6	4	7	4	9	2-2	2-2	2-8	2-6
AB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AC	3	1	1	2	6	7"	7	9	10	12"	14	15	17
AD	8	8	8	8	8	8	10	10	10	10	10	10	10
AE	20	18	17	2-1	2-4	3-5	3-2	3-11	4-8	6-1	5-10	7-0	7-1
AF									3-6	4-1	4-1	4-9	4-9
AG	2"	2"	2"	2"	3"	3"	3"	3"	3"	4"	4"	4"	4"
AH	16	9	10	16	14	18	18	21	3-6	2-4	2-7	2-9	3-0
AJ	15	12	10	17	18	2-5	2-0	2-6	3-0	4-2	3-8	4-8	4-5
AK	18	2-2	2-2	2-2	3-0	3-0	3-8	3-8	4-9	7-8	7-8	8-2	9-2
AL	2"	2	2	2	3"	3"	3"	3"	4"	4"	4"	4"	4"
AM	2-8	2-2	2-2	3-4	3-0	4-6	4-2	5-2	6-9"	7-9	7-9	9-2	9-2
AN	7"	8"	8"	9"	10"	11"	12"	12"	15"	15"	15"	15"	15"
AP	6-6	7-5	7-7	7-6	10-1	10-8	11-8	12-0	13-5	15-1	15-11	17-5	18-3
AQ	5-1	5-6	5-9	5-7	7-2	7-5	7-11	7-6	8-5	9-5	9-5	10-0	10-1
AR	5-0"	5-8"	5-8"	5-8"	7-0"	7-0"	7-6"	7-6"	7-6"	8-7"	8-7"	9-4"	9-4"
AS	2-5	2-5	2-5	2-5	2-11	2-11	3-5	3-5	2-4	2-6"	2-6"	2-6"	2-6"
AT	8-9	7-9	8-0	8-4	10-7	11-2	12-3	12-10	14-7	16-5	17-3	18-9	19-7
CAP. CU. FT.	10.5	13.1	13.1	18.6	27.7	39.2	50.2	61.6	72.9	163.3	163.3	248.7	248.7
AU	4"	4	3	7"	6"	9	10	13"	15	17	19	21	24
AW	2	3	1	2	2	1	2	3	2	1	2	1"	3



BASE DRILLING

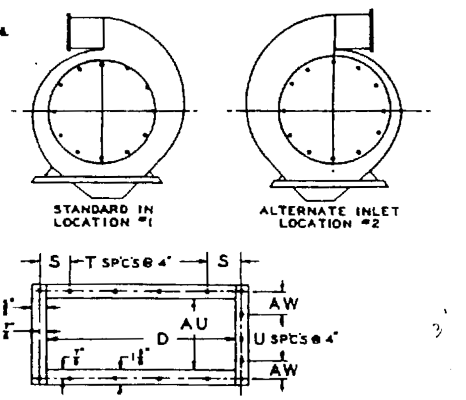


FIG. 1 INLET FLANGE DETAIL A.A.F. SKIMMER

DRAWN RICE	AMERICAN AIR FILTER COMPANY INC. LOUISVILLE, KENTUCKY	SUPERSEDES 87P-25294-B
DATE 12-3-57		
AAF SKIMMER WITH TYPE S HOPPER AND EXHAUSTER		DRAWING No. 87P-25294-C

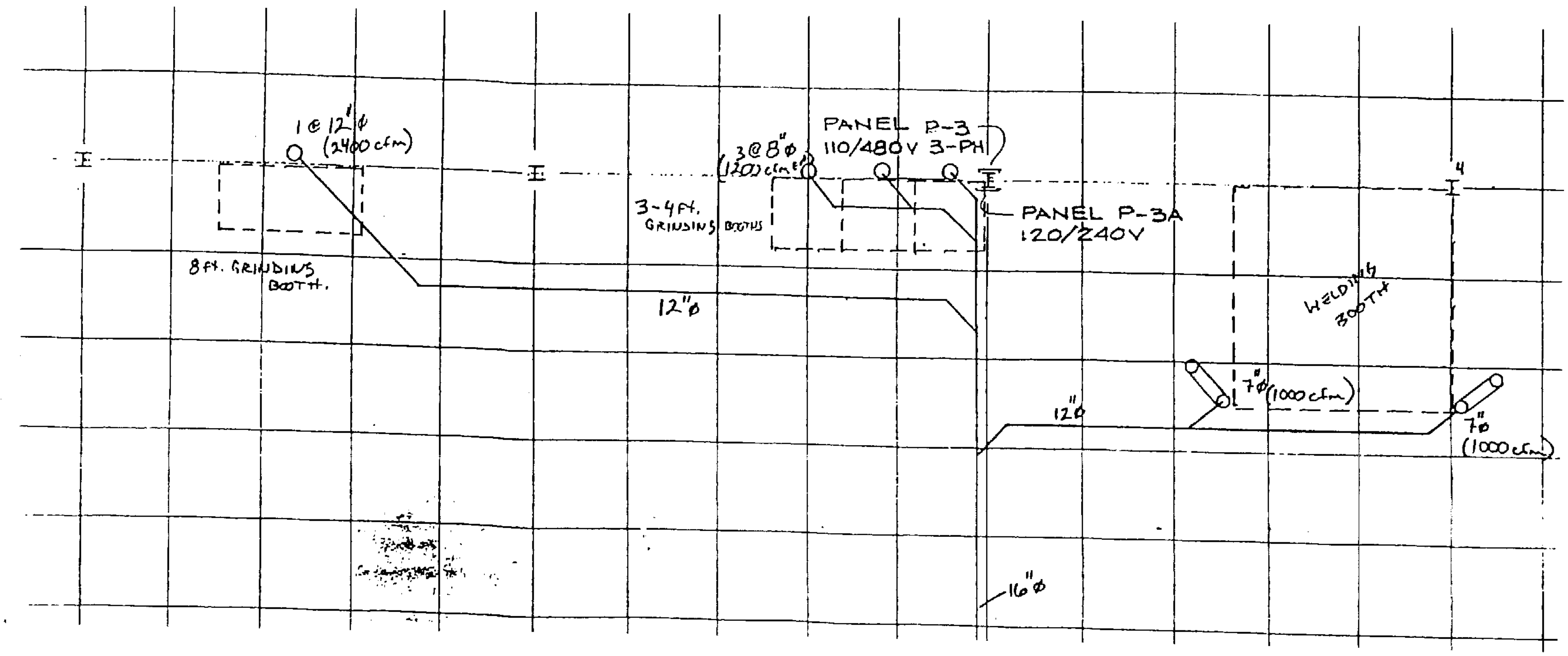
FOR AAF SKIMMER & TYPE S HOPPER 87P-28188
SEE REVERSE SIDE

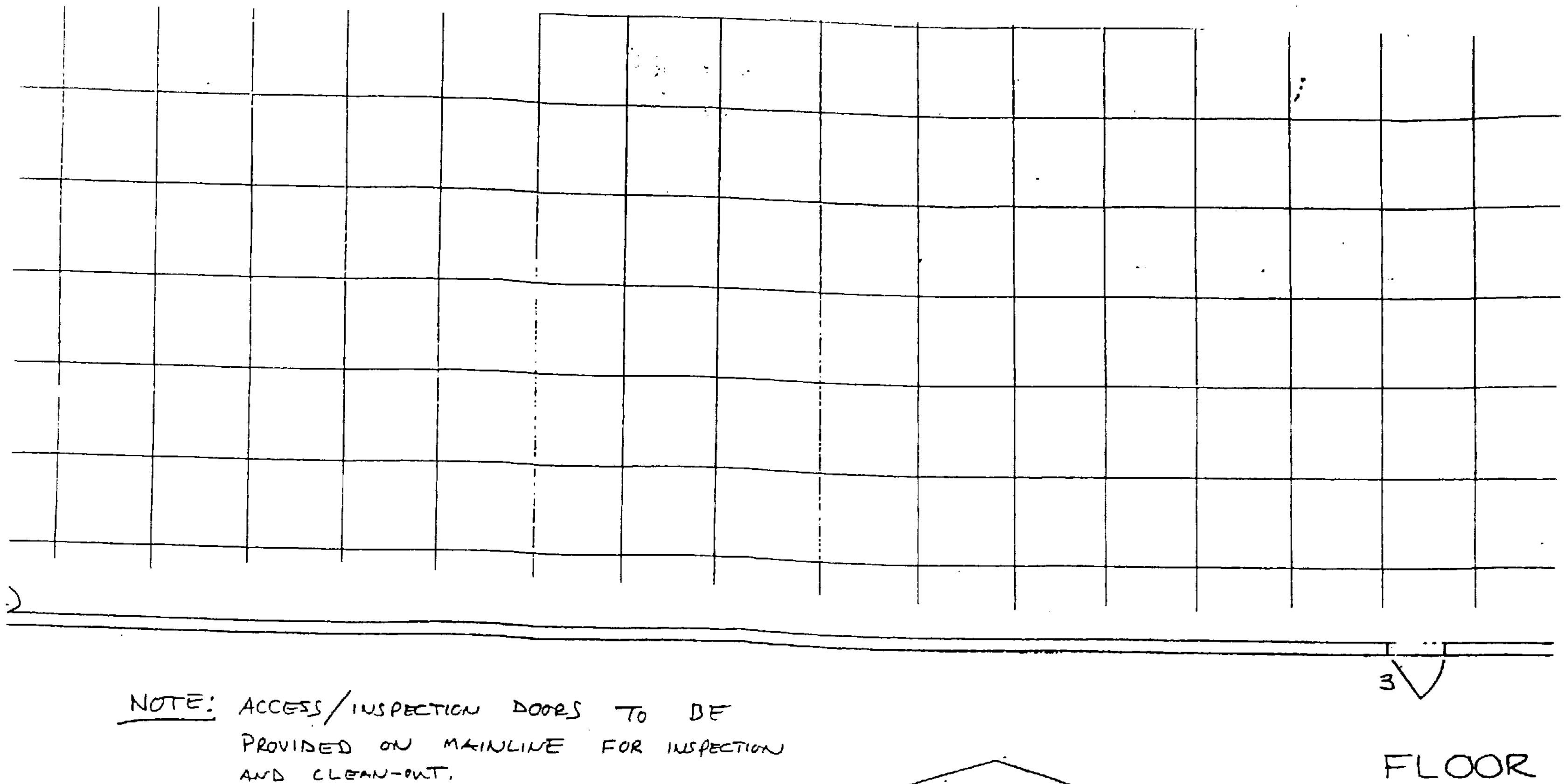
Page 70 - Site 19 - Enclosure 2

APPENDIX C

(4 pages follow)

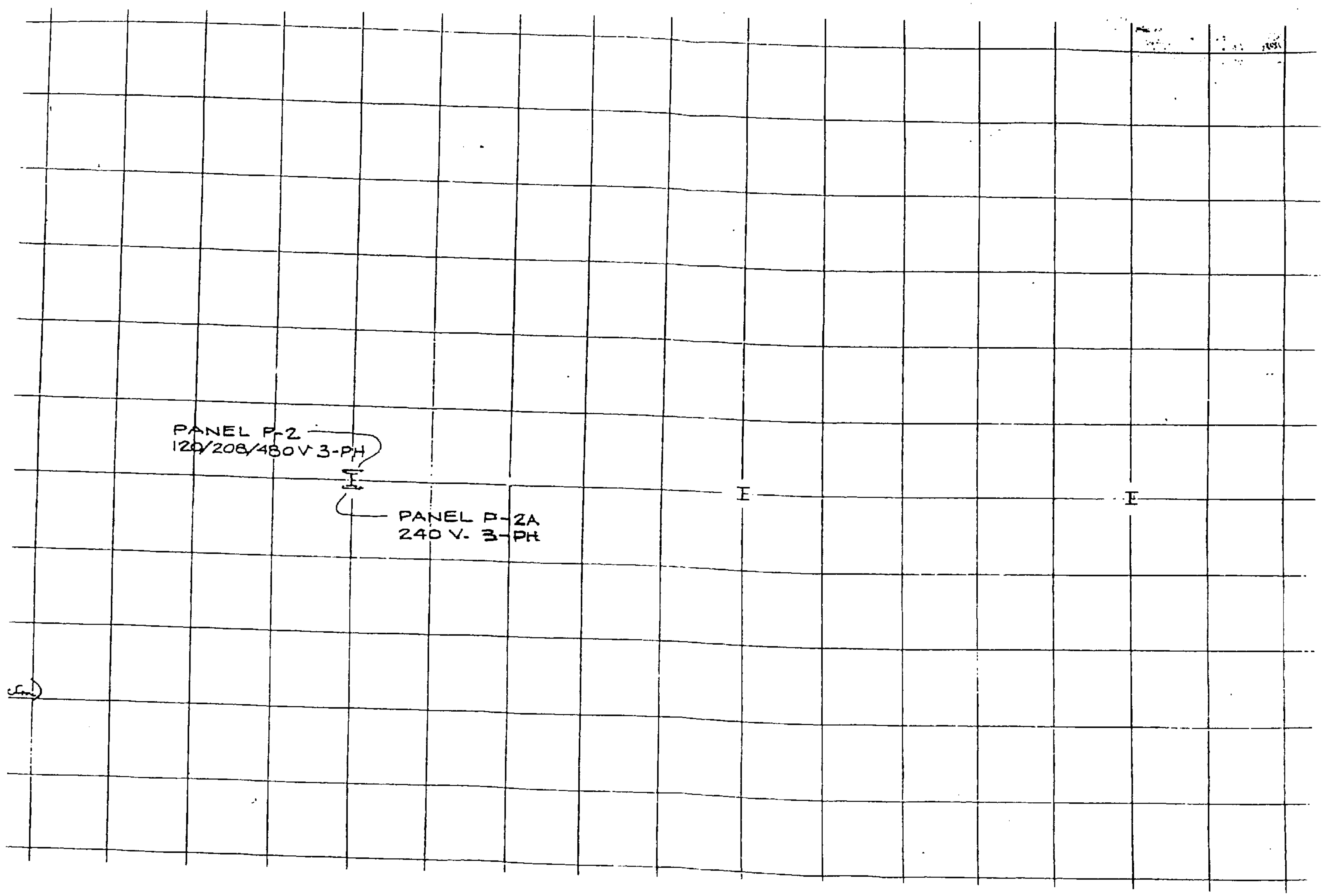
Newer Facility Proposed Ventilation Plans

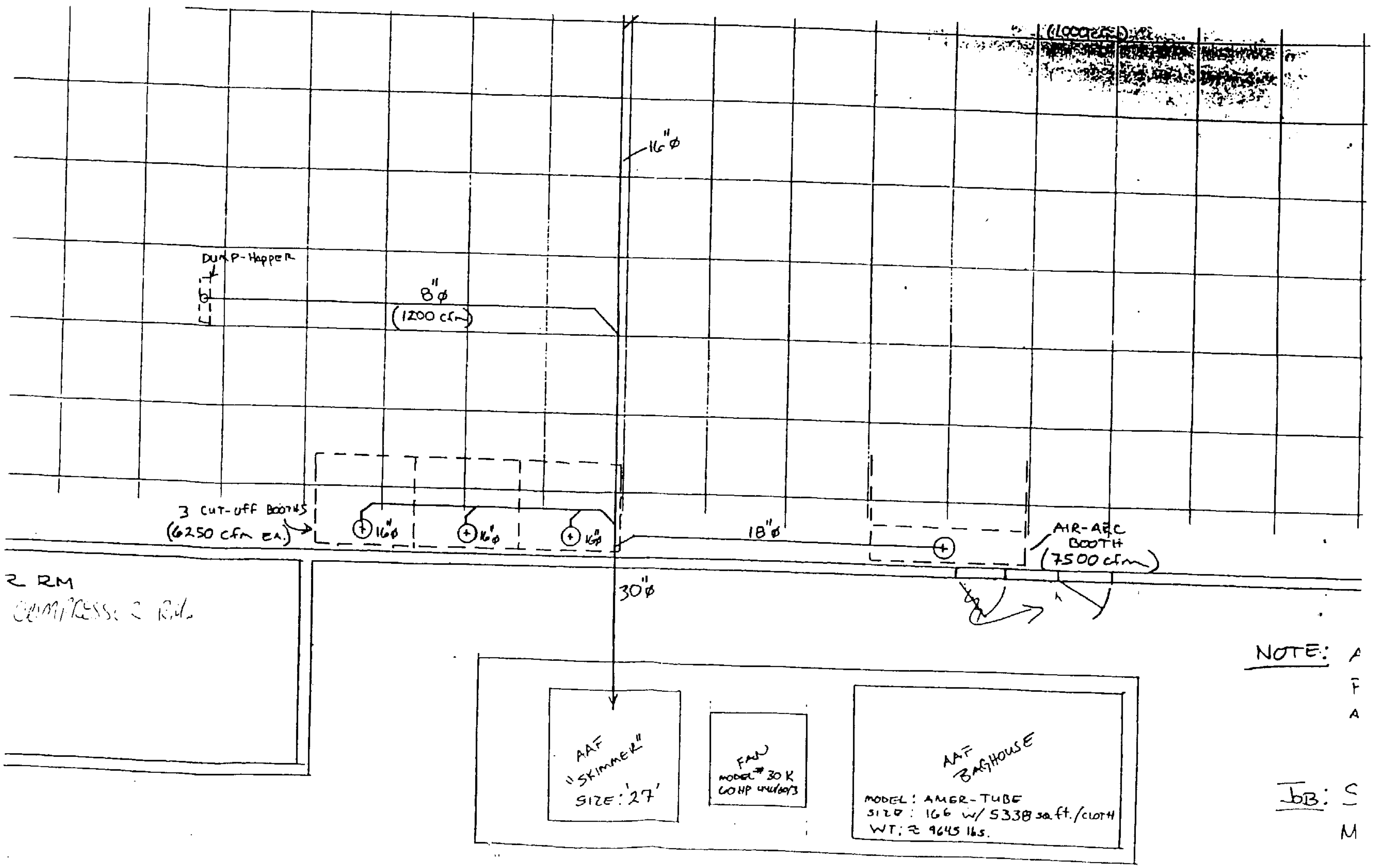

1 @ 12" ϕ (2400 cfm)
8 ft. GRINDING BOOTH.
12" ϕ
3 @ 8" ϕ (1200 cfm)
3-4 ft. GRINDING BOOTHS
PANEL P-3 110/480V 3-PH
PANEL P-3A 120/240V
16" ϕ
12" ϕ
7" ϕ (1000 cfm)
WELDING BOOTH
7" ϕ (1000 cfm)
4



NOTE: ACCESS/INSPECTION DOORS TO BE PROVIDED ON MAINLINE FOR INSPECTION AND CLEAN-OUT.

SCALE: 3/16" = 1' (1/64)


PANEL P-2
120/208/480V 3-PH
PANEL P-2A
240 V. 3-PH



16"ø
DUMP-HOPPER
8"ø
(1200 cfm)
3 CUT-OFF BOOTHS
(6250 cfm EA)
16"ø
16"ø
16"ø
18"ø
AIR-ARC BOOTH
(7500 cfm)
30"ø
AAF "SKIMMER"
SIZE: 27
FAN
MODEL # 30 K
60 HP
AAF BAGHOUSE
MODEL: AMER-TUBE
SIZE: 166 w/ 5338 sq. ft./CLOTH
WT: ≈ 9645 lbs.

NOTE:

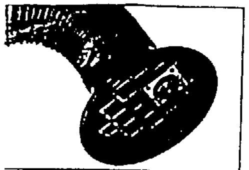
JOB:

Page 84 - Site 19 - Enclosure 2

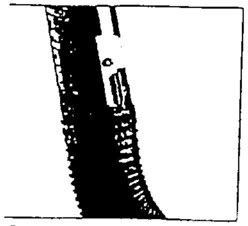
APPENDIX D

(2 pages follow)

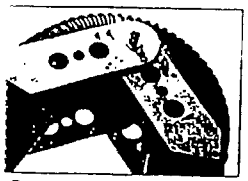
High Flow Fume Extractor



[illegible] The large 12" diameter inlet hood is spun [illegible]num with baked epoxy powder coat for durability [illegible] corrosion resistance. The unique minimal resistance [illegible] internal u-joint allows 180° movement. The 360° [illegible]ed handle is more user-friendly than single-handle [illegible]ns. This grab & go feature allows the user to [illegible]ly locate the handle without looking up or removing [illegible] helmet.



The optional positive locking damper allows for [illegible] control of airflow needed. This feature eliminates [illegible] drifting.



The patented friction-release joint plates engage [illegible]vely when positioned – yet offer no friction when [illegible] away from gravity. Operators don't have to wrestle [illegible] weight and friction, or worry about drooping hoses. [illegible]sult? The easiest movement and most positive [illegible]oning of any arm on the market.

Round high flow extractor ducts are formed of [illegible]um and finished with powder coat epoxy to better [illegible] industrial environments.

How to Build a Better Arm.

FROM BASE TO HOOD, BETTER MATERIALS AND SUPERIOR DESIGNS.

There is a reason why E-Z Arm™ looks different from other arms — and the reason is higher performance. The joints are Airflow Systems, Inc., patented* designs; the construction materials were chosen for their lightness and durability. The result: an arm that will work better and last longer.

(FAN NOT INCLUDED)

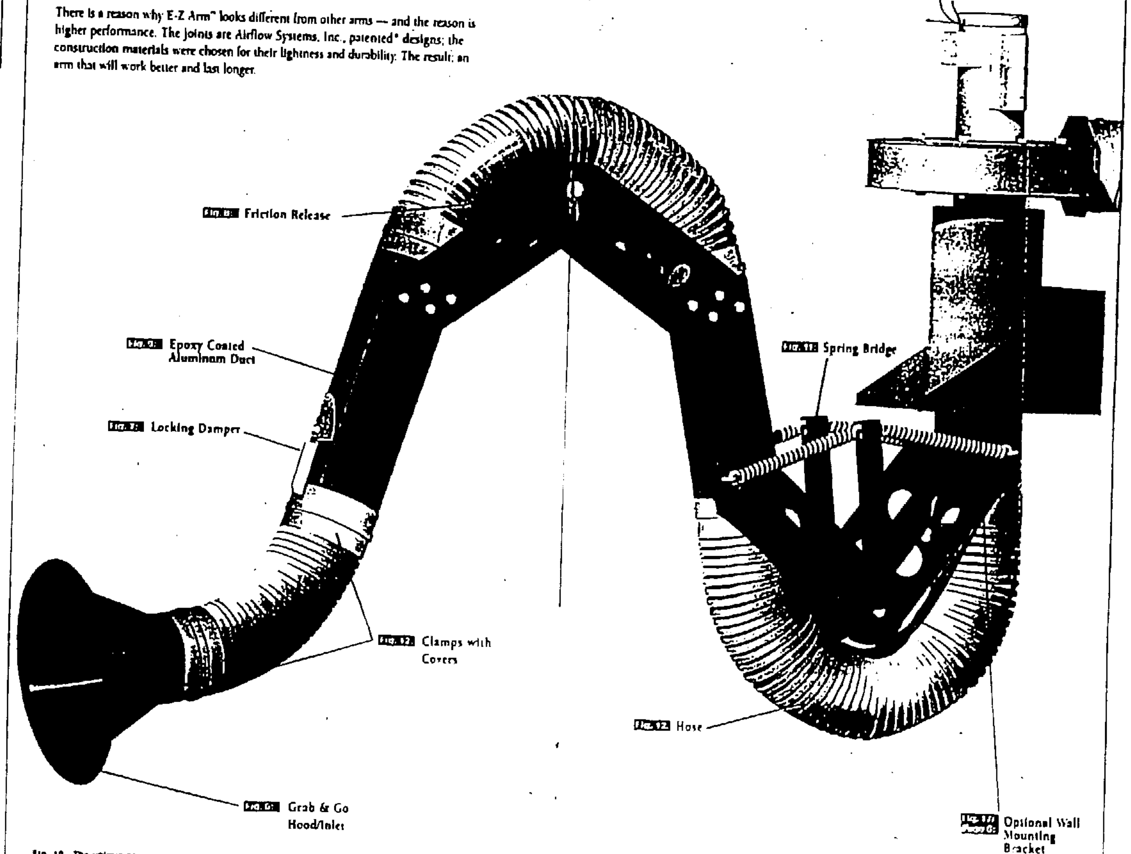


Fig. 10 The unique components that enhance E-Z Arm™ High Flow Extractor's performance

* U.S. Patent 5,536,306

SYSTEM COMPONENTS

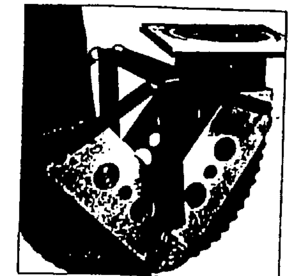


Fig. 11: The spring bridge counter-balance is a compact design that further enhances maneuverability. As important, the design eliminates potentially dangerous long external springs that require awkward safety cables. Joint plates are made of aluminum for low weight, high strength and improved appearance.

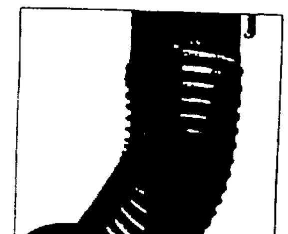


Fig. 12: E-Z Arm™ High Flow Extractor hose is made of specially designed thermoplastic rubber matrix, spiral wire-reinforced for strength and flexibility. The hose material is UL94HB rated for flammability and has high resistance to weld sparks and grinding embers. Note one piece clamp covers which add to overall appearance and provide an added measure of safety against loose or sharp edges.

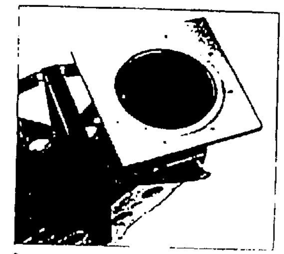


Fig. 13: The base [illegible] utilizes low friction HDPE bearing material. The [illegible] doubles as a labyrinth seal. The E-Z Arm™ High Flow Extractor is a bolt-on replacement for old style internally supported arms. Plus, we easily adapt to [illegible] Nederman® Plymovent [illegible] and Smogmog®

SPECIFICATIONS

Specifications and Applications

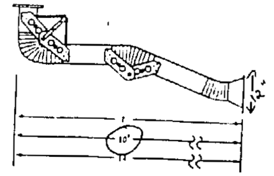


Fig. 14. Only E-Z Arm™ extractor allows you to use the full extension of the arm. Without drooping! This patented* feature allows you the maximum range of performance. The standard E-Z Arm™ can be specified in 7', 10' and 14' extension lengths.

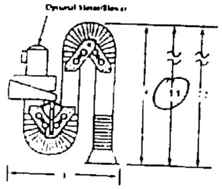


Fig. 15a. If off production storage is a concern as well as aesthetics, only E-Z Arm™ allows you to store in the most compact and efficient manner.

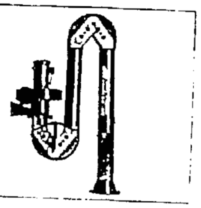


Fig. 15b

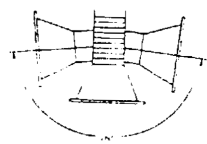


Fig. 16. The standard 13" inlet hood has a 160° range [illegible]

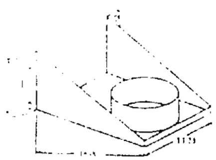


Fig. 17. The optional wall mounting E-Z Arm™ bracket.

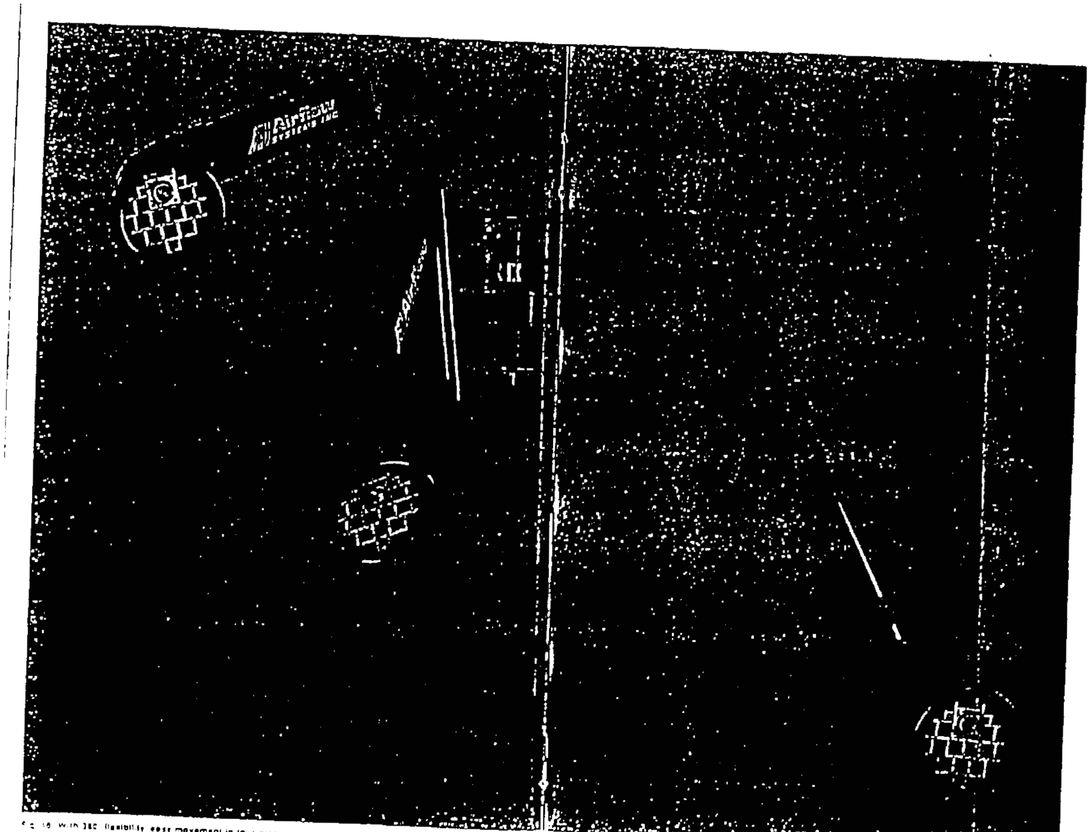


Fig. 18. With 360° flexibility, easy movement in four planes and positive positioning, the E-Z Arm™ extractor can reach to wherever the work is.

SYSTEM COMPONENTS

APPLICATIONS

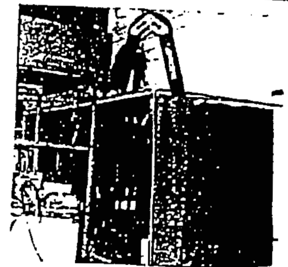


Fig. 19: Model F122 with two E-Z Arm™ High Flow Extractors in weld booth.

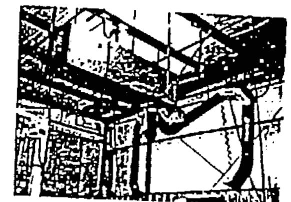


Fig. 20: Model F-122 with two E-Z Arm™ High Flow Extractors for large weldments to collect fumes and dust.

Fig. 21: A [illegible] E-Z Arm™ in a welding booth.

APPENDIX E

(2 pages follow)

Torit Baghouse For Existing Furnace Exhaust System in Older Facility

TORIT INSTALLATION AND OPERATION MANUAL

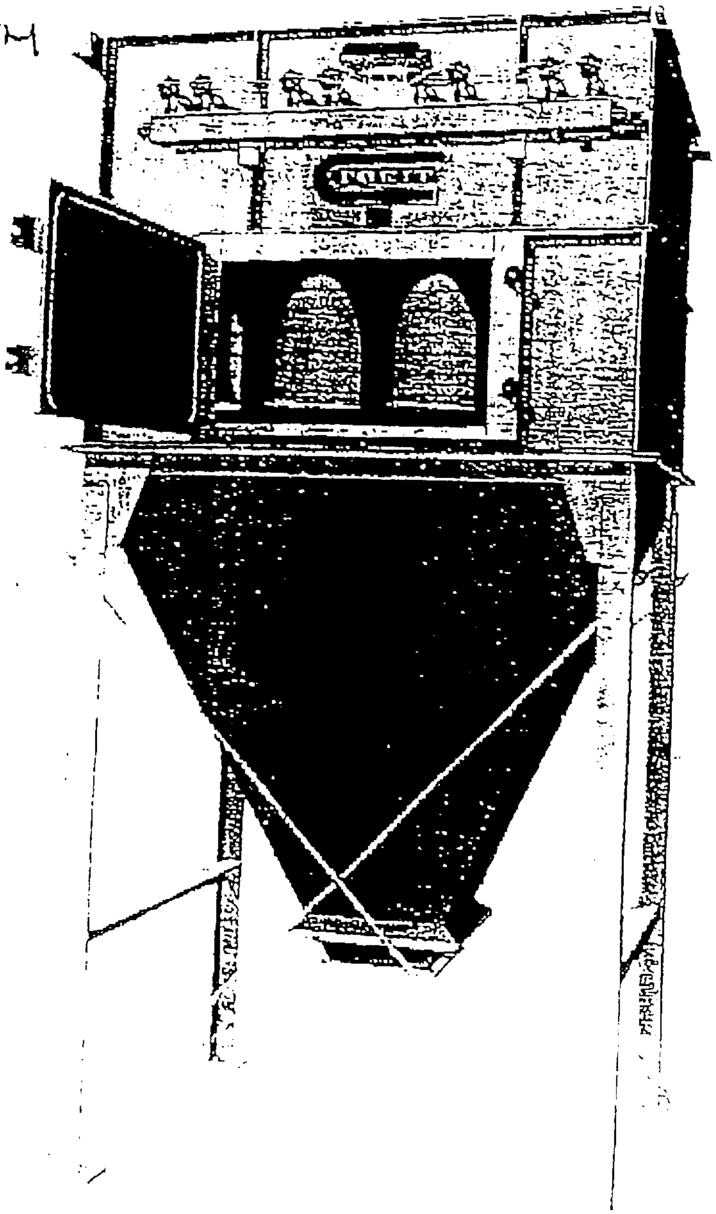
MODELS TD 1150 / TD 2300 / TD 3060 / TD 4600 / TD 6120

Includes Installation, Operation, Service Instructions, and Parts List

* 2500 TO 5000 CFM

HP = 20
Amps = 24.5
Volts = 480
Phase = 3
RPM = 1765
wt = 0.05
[illegible] Assembly Cost = $1500
CFM = 2500-5000
Filters = 99.9% 0.01-1 micron

With quick-change filter cartridges



NOTE

The T.D. Model 3060 Dust Collector is used for illustrative purposes throughout this manual. Part numbers and quantity differences for all models are shown in the parts list

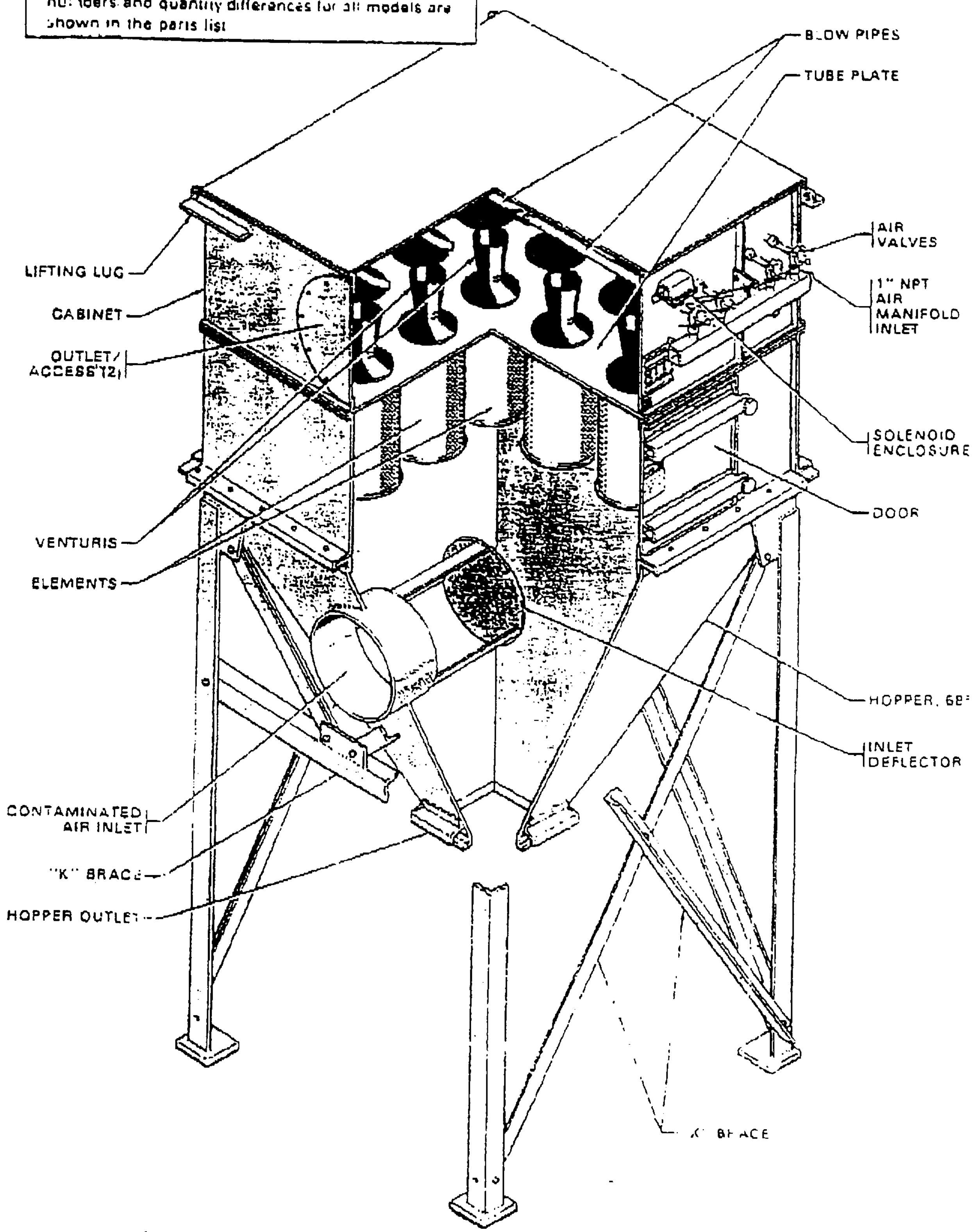


Fig 1

APPENDIX F

(10 pages follow)

Welding ASTM Specifications and Material Safety Data Sheets

BASE METALS

RODS/FILLER
RODS/FILLER

specification			alloy	TIG	STICK
ASTM	A747	CB7CU1	(17-4)	17-4 630	ER630-16
"	"	CB7CU2	(15-5)	"	"
ASTM	A743	CA6NM-A		410NIMO	ER410NIMO
ASTM	A487	CA6NM-B		ASK MARK	
ASTM	A743	CF8M	(316)	316 OR 316L	ER316L
"	"	CF3M	(316L)	"	"
ASTM	A743	CF8	(304)	308 OR 308L	ER308L
"	"	CF3	(304L)		
ASTM	A743	CF8C	(347)	347	
ASTM	A743	CG6MMN	(NITRONIC 50)	NI50	
ASTM	A743	CG8M	(317)	317	ER317-16
ASTM	A743	CN7M	CARPENTER 20	320	ER320-15
ASTM	A743	CA15	410	410	ER410-16
ASTM	A743	CF10SMNN	NITRONIC 60	NI60	C3315-16
ASTM	A890-4A	CD4MCU	—	ER CD4MCU-16	
ASTM	A890-5A		ZERON 100		ER-5A-16

ASTM A216 WCB	1025	ER70S	ER70S3M.
" " WC-A	WC-A	"	"
ASTM A732 7Q	4130	"	"
" " 8Q	4140	"	"
" " 13Q	8620	"	"
" " 14Q	8630	"	"
ESCO 12F	ESCO12F	"	"
ESCO 12S	ESCO12S	"	"
49K	—	ER309	ER309-L
ASTM	CE3MN	OK ~~68~~55	

Aluminum

H-1236-L
Revision Date 1/87

INCO ALLOYS INTERNATIONAL, INC.
Material Safety Data Sheet
Welding Products
NI-ROD®

Inco Alloys International, Inc.
Welding Products Company
1401 Burris Road
Newton, N. C. 28658

NI-ROD
#320

SECTION 1 - Product Identification

This MSDS covers all Inco Alloys International, Inc. welding products identified as:
NI-ROD® Welding Electrodes and Cored Wire
Trade name and nominal composition are listed in Section 2-A

SECTION 2 - Hazardous Ingredients

IMPORTANT This section covers the materials contained in the product as shipped. The fumes and gases produced during welding are covered in Section 6.

Ingredient	CAS No.	PEL(1)	TLV(2)	Ingredient	CAS No.	PEL(1)	TLV(2)
Aluminum (Al)	7429-90-5	NONE	10	Iron (Fe)	7439-89-6	NONE	NONE
Barium Carbonate ($BaCO_3$)	513-77-9	0.5 (as Ba)	0.5 (as Ba)	Iron Oxide (Fe_2O_3)	1309-37-1	10	5
Barium Fluoride (BaF_2)	7787-32-8	0.5 (as Ba)	0.5 (as Ba)	Manganese (Mn)	7439-96-5	C5	C5
Calcium Carbonate ($CaCO_3$)	1317-65-3	NONE	10	Sodium Aluminum Fluoride (Na_3AlF_6)	15096-52-3	2.5 (as F)	2.5 (as F)
Calcium Fluoride (CaF_2)	7789-75-5	2.5 (as F)	2.5 (as F)	Nickel (Ni)	7440-02-0	1	1
Carbon (C)	7440-44-0	3.5	3.5	Silicon Dioxide (SiO_2)	60676-86-0	0.1	0.1
Copper (Cu)	7440-50-8	1	1	Strontium Carbonate ($SrCO_3$)	1633-05-2	NONE	NONE

SECTION 2 A - Tradename and Nominal Composition

Wt. % of combined wire and flux 1% or greater
1-10% A 11-30% B 31-60% C 61-100% D

PRODUCT NAME	Al	$BaCO_3$	BaF_2	$CaCO_3$	CaF_2	C	Cu	Fe	Fe_2O_3	Mn	Na_3Al_6	Ni	SiO_2	$SrCo_3$
NI-ROD® Welding Electrode	A	A	A			A		A				D	A	A
NI-ROD® 44 Welding Electrode			A	A		A	A	C		A		C	A	A
NI-ROD® 55 Welding Electrode			A	A		A	A	C				C	A	A
NI-ROD® 55X Welding Electrode	A		A	A		A	A	C				C	A	A
NI-ROD® 60 Welding Electrode			A	A		A	A	C	A			C	A	A
NI-ROD® 99X Welding Electrode			A	A		A	A	A		A		D	A	A
NI-ROD® FC55 Cored Wire			A	A	A			C		A	A	C		

® Registered Trademarks of the Inco family of companies

SECTION 3 - Physical Data

Welding electrodes are solid alloy wire which is flux coated or may have a flux core.

SECTION 4 - Fire and Explosion Data

Nonflammable; however, welding arcs and sparks can ignite flammable liquids and vapors and combustible solids.

Notes: As defined by OSHA (29CFR1910.1200) or certain state regulations.
1. Permissible Exposure Limit - (mg/m³) OSHA (29CFR1910.1000). C = Ceiling Value
2. Threshold Limit Value - (mg/m³) American Conference of Governmental Industrial Hygienists (current as of MSDS revision date). C = Ceiling Value

SECTION 5 - Health Hazard Information

Exposure Limits: Section 2 lists specific hazardous ingredients and exposure limits. Section 6 lists exposure limits for hazardous reaction products that might be formed by welding and high temperature cutting. IMPORTANT - Determine actual exposure by industrial hygiene monitoring.

POSSIBLE SIGNS AND SYMPTOMS OF EXPOSURE TO DUST, WELDING FUME AND GASES

SHORT TERM EXPOSURE:
Metallic taste; nausea; tightness of chest; fever; irritation of eyes, nose, throat and skin; loss of consciousness/death due to welding gases or lack of oxygen.

LONG TERM EXPOSURE:
Adverse effects may result from long time exposure to welding fume, gases, or dusts. These effects may include skin sensitization, neurological damage and respiratory disease such as bronchial asthma, lung fibrosis or pneumoconiosis. Nickel and chromium must be considered possible carcinogens under OSHA (29CFR1910.1200). The National Toxicology Program (NTP) has listed nickel as a possible cancer hazard. The International Agency for Research on Cancer (IARC) concluded there was sufficient evidence that nickel refining was carcinogenic to humans and limited evidence that nickel and certain nickel compounds were carcinogenic to humans. IARC could not state with certainty which forms of nickel are human carcinogens but said "...metallic nickel seems less likely to be so than nickel subsulphide or nickel oxides." The inhalation of nickel powder has not resulted in an increased incidence of malignant tumors in rodents. Studies of workers exposed to nickel powder and to dust and fume generated in the production of nickel alloys and of stainless steel have not indicated a respiratory cancer hazard. For chromium exposures the NTP and IARC conclude there is sufficient evidence in the chromate-producing industry and possible evidence in chrome platers and chromium alloy workers for an increased incidence of lung cancer. Recent epidemiological studies of workers melting and working alloys containing nickel/chromium have found no increased risk of cancer. Nevertheless, exposures MUST be maintained below the levels specified in Sections 2 and 6.

AGGRAVATION of preexisting respiratory or allergic conditions may occur in some workers.

EMERGENCY AND FIRST AID
Remove from exposure and obtain prompt medical attention. If victim is unconscious, administer oxygen. If not breathing, resuscitate immediately.

SECTION 6 - Reactivity Information

Hazardous Reaction Products:
Fumes and gases from welding and high temperature cutting cannot be classified simply. The composition and quantity of both depend on the metal being welded, the process, procedures, and electrodes used. The constituents of the fume are generally different from the ingredients listed in Section 2 and may include oxides and mixed oxides of the metals, chromates, and fluorides. The gases may include carbon monoxide, ozone, and oxides of nitrogen. Chlorinated solvents may be decomposed by the arc into toxic gases such as phosgene. The following exposure limits apply to those fumes and gases which may be found in the welding or high temperature cutting environment.

Substance	PEL	TLV	Substance	PEL	TLV
Aluminum fume (Al)	NONE	5.0	Manganese fume (Mn)	C5.0	1.0
Carbon monoxide (CO)	50ppm	50ppm	Molybdenum (soluble) (Mo)	5.0	5.0
Chromium (Chromates)	C0.1	0.05	Nickel (soluble) (Ni)	1.0	0.1
Cobalt fume (Co)	0.1	0.1	Nitrogen dioxides (NO_2)	C5.0ppm	3ppm
Copper fume (Cu)	0.1	0.2	Ozone (O_3)	0.1ppm	0.1ppm
Fluorides (as F)	2.5	2.5	Phosgene ($COCl_2$)	0.1ppm	0.1ppm
Iron oxide fume (as Fe)	10.0	5.0			

(PEL/TLV values are mg/m^3 except where indicated as ppm) C = Ceiling value

SECTION 7 - Spill or Leak Procedures

Vacuum or shovel any spilled material into a suitable container. Dispose in accordance with EPA, State or Local regulations.

SECTION 8 - Special Protection Information

Respiratory Protection:
Necessary when permissable exposure limits may be exceeded during cutting, grinding, or welding. Use air-supplied respirator in confined spaces. — Use only NIOSH approved respirator in accordance with 29CFR1910.134

Ventilation:
Use local exhaust when cutting, grinding, or welding. IMPORTANT - maintain exposures below the limits in Section 2 and 6. Confined spaces require special attention to provision of adequate ventilation.

Eye Protection and Protective Clothing: Required when cutting, grinding, or welding. Wear gloves, face protection, and flame retardant clothing. Do not expose skin. Select welding lense shade from AWS publication F2.2.

SECTION 9 - Special Precautions

IMPORTANT - Maintain exposures below the PEL/TLV. Use industrial hygiene air monitoring to ensure that your use of this material does not create exposures which exceed PEL/TLV. Always use exhaust ventilation. Refer to the following sources for important additional information:

ANSI Z49.1 The American Welding Society, P. O. Box 351040, Miami, FL 33135

OSHA (29CFR1910) U.S. Dept. of Labor, Washington D.C. 20210

ARC Rods AIR ARC (CARBON) #201

MATERIAL SAFETY DATA SHEET

ARCAIR COMPANY
3010 Columbus-Lancaster Road
Lancaster, Ohio 43130

Emergency Telephone No.: (614) 653-5618

AIR CARBON ARC ELECTRODES

I. PRODUCT IDENTIFICATION

Trade Name	Chemical Composition
Copperclad Electrodes	Carbon
Jetrods Electrodes	Graphite
Arcair R Gouging Electrodes	Copper
Air Carbon Arc Electrodes	

II. HAZARDOUS INGREDIENTS

The electrode rod consists of three common materials--carbon graphite and copper. These chemicals in the form of a rod pose no unusual hazard to human health or the environment. When this rod is used as intended, however, hazards do exist of which the user must be aware to prevent harm to himself and others around him. Potential hazards arising during the use of gouging electrodes include electrical shock, toxic fumes and gases, fire, hot metal sparks, direct and reflected heat, excessive noise and eye-endangering UV rays. All of these hazards can be avoided by following safe work practices.

III. PHYSICAL DATA

The electrode is a blend of carbon and graphite in the form of a rod and coated with copper. Rods are available in various types and sizes. Arcair air carbon arc electrodes are designed for use in an Arcair torch connected to an ordinary welding power supply and compressed air source. Electrodes are specially formulated and baked to remove all moisture. Precautions should be taken to keep the electrodes dry. Electrodes that have been exposed to moisture should never be used unless they are thoroughly dried for 10 hours at 300 F. Moist electrodes may shatter violently when used.

IV. FIRE AND EXPLOSION HAZARD DATA

Heat is generated by the electric arc created between the electrode and the work. Metal is melted at the point of contact and blown away with a jet of compressed air. Arc metal sparks and molten metal spray can ignite combustible materials in the vicinity of gouging operations and cause a fire. Keep combustible materials such as paper, rags, organic solvent and fuels outside of the work area or protected from sparks and metal spray.

Cutting of containers that hold or have held flammable or combustible materials may cause an explosion. Clean empty containers thoroughly to make absolutely certain that no flammable materials are present, or other materials which, when heated might product flammable or toxic vapors.

Booths, metal screens or other deflecting means should be positioned to catch harmlessly the hot metal and particulate sparks sprayed by the compressed air stream.

V. HEALTH HAZARDS

Air carbon arc gouging may produce fumes and gases which can be dangerous to your health. Adequate ventilation is required to keep the amount of toxic fumes and gases below the prevailing time-weighted average (TWA) threshold limit value (TLV).

The American Conference of Governmental Industrial Hygienists (ACGIH-1980) recommended threshold limit for welding fume NOC-(not otherwise classified) is 5 mg/m3. The ACGIH 1980 preface states, 'The TWA-TLV should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations.' See Section VI for specific fume constituents which may modify this TLV.

Exposure to fumes and gases can cause bronchitis and deposits in the lung. Material deposited in the lung may impair lung function and cause tissue damage which may be irreversible (permanent damage). Short-term exposure to welding fumes may result in discomfort such as dizziness, nausea, or dryness or irritation of nose, throat, or eyes.

The light flash and arc rays (radiant energy) created during gouging operations contains injurious UV (ultra-violet) rays which can cause keratitis and conjunctivitis in improperly protected eyes. Helpers and other employees in areas adjacent to the cutting operation also should wear eye protection.

Flying sparks and molten metal contacting unprotected skin or eyes will cause burns. Also, hands or other parts of the body which are permitted to come close to the active arc may be burned. Protective clothing, face shield and goggles shall be worn.

Electric shock will occur when the user permits the "live" (energized) metal parts of an electrode to touch his skin or any wet covering on his body. Electric shock can kill. Do not touch live electrical parts. Dry clothing and gloves should be worn.

Continuous gouging operations may generate noise levels in excess of acceptable limits. Repeated exposure to excessive noise may cause temporary or permanent hearing loss. If this occurs, use ear protective equipment.

FIRST AID: If overexposure to fumes occurs, remove victim to fresh air. If breathing is impaired, assisted respiration (preferably mouth-to-mouth) may be necessary. Seek medical advice. For electrical shock, turn off power and remove victim from contact. If not breathing, administer CPR. Call a physician. For burns, apply clean, cold (iced) compresses.

VI. REACTIVITY DATA

The electrode is made up of chemicals which are stable under normal conditions. Hazardous decomposition products can occur during normal use of the cutting rod.

Gouging fumes and gases cannot be classified simply. The composition and quantity of both are dependent upon the metal being gouged, the process and electrodes used. Other conditions which also influence the composition and quantity of the fumes and gases to which workers may be exposed include: coatings on the metal being gouged (such as paint, plating, or galvanizing), the number of operators and the volume of the work area, the quality and amount of ventilation, the position of the operator's head with respect to the fume plume, as well as the presence of contaminants in the atmosphere (such as chlorinated hydrocarbon vapors from cleaning and degreasing activities).

When the electrode is consumed, the fume and gas decomposition products generated are different in percent and form from the ingredients listed in Section II. Decomposition products of normal operation include those originating from the volatilization, reaction, or oxidation of the materials shown in Section II, plus those from the base metal and coating, etc., as noted above.

Reasonably expected fume constituents of this product could include: primarily oxides of copper and iron; secondarily complex oxides of manganese, silicon, titanium, and sodium.

When gouging stainless steel, fume constituents would include: primarily fluorides and complex oxides of copper, iron and silicon; secondarily complex oxides of manganese, titanium chromium, nickel, sodium and potassium. The present OSHA TLV for hexavalent chromium (Cr VI) is 0.05 mg/m3 which will result in a significant reduction from the 5 mg/m3 general welding fume (NOC) threshold limit.

Gaseous reaction products may include carbon monoxide and carbon dioxide. Ozone and nitrogen oxides may be formed by the radiation from the arc.

One recommended way to determine the composition and quantity of fumes and gases to which workers are exposed is to take an air sample from inside the welder's helmet if worn or in the worker's breathing zone. See ANSI/AWS F1.1-78, available from the American Welding Society, 550 N.W. Lejeune Road, Miami, Florida 33126.

VII. SPILL OR LEAK PROCEDURES

Electrodes or portion of electrodes may be disposed in a landfill.

VIII. SPECIAL PROTECTION INFORMATION

Read and understand the manufacturer's instructions and precautionary label on the product. The operation and maintenance of cutting and gouging equipment shall conform to the provisions of the American National Standard Z49.1, "Safety in Welding and Cutting" published by the American Welding Society, 550 N.W. Lejeune Road, Miami, Florida 33126 and the OSHA Standards for General Industry, Subpart Q-Welding Cutting and Brazing (29 CFR Part 1910.252) available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Ventilation is required to keep the level of toxic fumes, gases and dust below the threshold limit values (TLV's) established by the American Conference of Governmental Industrial Hygienists (ACGIH). Natural, mechanical or local exhaust ventilation may be used. In circumstances where it is not possible to provide ventilation, air-supplied respirators or respirable fume respirators must be used. Where ventilation may be questionable, air sampling should be used to determine if corrective measures should be applied. Use enough ventilation and/or exhaust at the arc to keep fumes from the breathing zone.

Wear helmet or use face shield with filter lens shade number 2 (two) or darker. Provide protective screens, barrier curtains, and flash goggles, if necessary, to shield others.

Wear hand, head, and body protection which help to prevent injury from radiation, sparks, and electrical shock. See Z49.1. At a minimum this includes welder's gloves and a protective face shield, and may include arm protectors, aprons, hats, shoulder protection, as well as dark substantial clothing. Train the welder not to touch live electrical parts.

Ear protection devices are recommended.

IX. SPECIAL PRECAUTIONS

Precautionary Label
WARNING: Protect yourself and others. Read and understand this label.
FUMES AND GASES can be dangerous to your health. ARC RAYS can injure eyes and burn skin. ELECTRIC SHOCK can kill. NOISE can damage hearing.

- **Read and understand the manufacturer's instructions and your employer's safety practices.**
- **Keep your head out of the fumes.**
- **Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone, and the general area.**
- **Wear correct eye, ear and body protection.**
- **Do not touch live electrical parts.**
- **See American National Standard Z49.1 "Safety in Welding and Cutting" published by the American Welding Society, 550 N.W. Lejeune Road, Miami, Florida 33126; OSHA Safety and Health Standards 29 CFR 1910, available from U.S. Government Printing Office, Washington, D.C. 20401.**

DO NOT REMOVE THIS LABEL

This Material Safety Data Sheet is furnished without charge to responsible persons who use it at their discretion and risk. Although the information and suggestions contained herein have been compiled from sources believed to be reliable, there is no warranty of any kind, express or implied, as to the completeness or accuracy thereof.

Form No. 89-250-823
February 1984

8.9

7294 —

Chicago/Wellsville Fire Brick Co.
Safety and Health
Material Safety Data Sheet

SECTION I

Manufacturer's Name: WELLSVILLE FIRE BRICK CO.
WEST HIGHWAY 19
WELLSVILLE, MO. 63384

Date: 11/10/89

Emergency Telephone Number: 314-684-2222

Trade Name and Synonyms: BANNER S.D. FIRE BRICK (BNR)

Chemical Family: Refractory Brick Shape

Chemistry:

Al_2O_3 - 42.0
SiO_2 - 52.7
Fe_2O_3 - 1.2
TiO_2 - 2.3
CaO - 0.4
MgO - 0.2
Alkali - 1.0

H.M.I.S. Designation

HEALTH ---------------- 2
FLAMMABILITY --------- 0
REACTIVITY ---------- 0
PERSONAL PROTECTION - E

SECTION II - HAZARDOUS INGREDIENTS

Material Name	%	C.A.S. #	TLV-TWA	SARA Title III List
Mullite	50-60	1302-93-8	Not established	NA
Glass	15-25		5 mg/m3	NA
Cristobalite	20-30	14464-46-1	.05 mg/m3	NA

SECTION III - PHYSICAL DATA

Boiling Point: NA
Vapor Pressure: NA
Vapor Density: NA

Solubility in Water: NA
Percent Volatile: NA
Evaporation Rate: NA

Specific Gravity: 2.7
Appearance: Pre-fired Brick Shape
Odor: None

Note: NA = Not appplicable
P = Proprietary Level > 1%

SECTION VII - REACTIVITY DATA

Stability: Product is stable

Hazardous Polymerization: Will not occur

Incompatibility: NA

Hazardous Decomposition Products: NA

SECTION VIII - SPILL OR LEAK PROCEDURES

Steps To Be Taken If Material Is Released Or Spilled
Normal clean up. Avoid generating dust.

Waste Disposal Method
Dispose of in accordance with appropriate Federal, State, and local regulations.

SECTION IX - SPECIAL PRECAUTIONS

Precautions To Be Taken In Handling And Storing
Avoid storing in damp areas.

Other Precautions
Change of work clothing recommended if contaminated with material.

The information and recommendations contained in this Material Safety Data Sheet are supplied pursuant to 29 CFR1910.1200 of the Occupational Safety and Health Standards Hazard Communication Rule. The information and recommendations set forth herein are presented in good faith and believed to be correct as of the date of this MSDS. Chicago/Wellsville Fire Brick Co. however, makes no representations as to the completeness or accuracy thereof, and information is supplied upon the express condition that the persons receiving same will be required to make their own determination as to the suitability for their purposes of use. In no event will Chicago/Wellsville Fire Brick Co. be responsible for any damages of any nature whatsoever resulting from the use of, reliance upon, or the misuse of this information.

NO REPRESENTATION OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OF ANY OTHER NATURE, ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OF THE PRODUCT TO WHICH INFORMATION REFERS.

This information as supplied herein is simply to be informative and intended solely to alert the user of the substance which is the matter of this MSDS. The ultimate compliance with federal, state, or local regulations concerning the use of this compound, or compliance with respect to products liability, rest solely upon the purchaser thereof.

PATCH-2-75
#431

MATERIAL SAFETY DATA SHEET

SECTION I. NAME AND PRODUCT

MANUFACTURER'S NAME Allied Mineral Products, Inc	CONTACT David M. M...
ADDRESS (STREET, CITY, STATE AND ZIP CODE) 2700 Scioto Parkway, Columbus, Ohio 43220	EMERGENCY TELEPHONE NO 614.876-024...
TRADE NAME, COMMON NAME OR SPECIFICATION MINRO-Z PATCH Z75	APPROVED BY: DB DATE 8/20/85
CHEMICAL FAMILY OR PRODUCT TYPE ZIRCON REFRACTORY	

SECTION II. REGULATED INGREDIENTS*

CHEMICAL NAME	COMMON NAME	OSHA PERMISSIVE EXPOSURE LIMIT	ACGIH TLV	CARCINOGEN (Y N)
Zirconium Silicate	Zircon	5 mg/M^3	5 mg/M^3	N
Proprietary	Ingredient	15 mg/M^3	10 mg/M^3	N

*Regulated as per lists: OSHA 29CFR 1910, subpart Z; ACGIH, HHS/NTP; & IARC.

SECTION III. PHYSICAL AND CHEMICAL DATA

Boiling Point	N/A	Melting Point	3400°F	Specific Gravity	3.2
Vapor Pressure	N/A	Percent Volatile by Vol.	N/A	Vapor Density	N/A
Evaporation Rate	N/A	Solubility in Water	N/A	Solubility in Alcohol	N/A
Solubility in Other Solvent	N/A	Appearance and Odor	Tan granular to fine material – no odor		

SECTION IV. FIRE AND EXPLOSION HAZARD DATA

Flash Point	N/A	(Method Used)	N/A	Flammable Limits LEL - N/A	UEL -
Extinguishing Media	N/A				
Special Fire Fighting Procedures	N/A				
Explosion Potential	N/A				

SECTION V. HEALTH, FIRST AID AND MEDICAL DATA

Primary Routes of Entry	Acute and Chronic Health Effects And Effects of Overexposure	First Aid and Medical Information
Inhalation	Irritant	Remove to fresh air.
Ingestion	NAIF	Drink plenty of water. Consult a physician.
Skin	Irritant	Wash with plenty of water.
Eye	Irritant	Flush immediately and repeatedly with water and consult a physician.
Other Potential Health Risks	NAIF	NAIF

SECTION VI. CORROSIVITY AND REACTIVITY DATA

Stability: Unstable ______ Stable X   Hazardous Polymerization: May Occur ______ Will Not Occur X

INCOMPATIBILITY (MATERIALS TO AVOID)

N/A

DECOMPOSITION PRODUCTS

N/A

CONDITIONS TO BE AVOIDED

N/A

SECTION VII. STORAGE, HANDLING AND USE PROCEDURES

NORMAL STORAGE AND HANDLING

Keep dry. Avoid exposure to moisture during storage. Avoid creating dust.

NORMAL USE Use proper procedures for installation and operation. Do not breathe dust. Wear approved respirator during installation and removal of product.

STEPS TO BE TAKEN IN CASE OF LEAKS OR SPILLS

Clean up. Avoid breathing dust. Wear approved respirator.

WASTE DISPOSAL METHOD

Any approved solid waste disposal method.

SECTION VIII. PERSONAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFY TYPE)	As specified in OSHA Std. CFR 1910.134	
VENTILATION	LOCAL	Recommended
	MECHANICAL (GENERAL)	N/A
	OTHER	N/A
PROTECTIVE GLOVES	Recommended	
EYE PROTECTION	Safety glasses	
OTHER EQUIPMENT	N/A	

MEASURES TO BE TAKEN DURING REPAIR AND MAINTENANCE OF CONTAMINATED EQUIPMENT THAT HAS BEEN IN CONTACT WITH THIS MATERIAL

Avoid breathing dust. Wear approved respirator.

SECTION IX. SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: N/A

OTHER PRECAUTIONS Steam spalling, which can lead to personal injury, may result from improper drying and firing.

**NAIF NO APPLICABLE INFORMATION FOUND   ** N/A NOT APPLICABLE